Minerals yearbook: Metals, minerals, and fuels 1973. Year 1973, Volume 1 1973

Minerals Yearbook 1973

Volume I

METALS, MINERALS, AND FUELS

Prepared by staff of the

BUREAU OF MINES

UNITED STATES DEPARTMENT OF THE INTERIOR • Stanley K. Hathaway, Secretary

BUREAU OF MINES • Thomas V. Falkie, Director

As the Nation's principal conservation agency, the Department of the Interior has basic responsibilities to protect and conserve our land and water, energy and minerals, fish and wildlife, and park and recreation areas, and for the wise use of all those resources. The Department also has a major responsibility for American Indian reservation communities and for the people who live in Island Territories under U.S. administration.

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Foreword

The Federal Government, through the medium of the Minerals Yearbook or its predecessor volumes, has for 91 years reported annually on mineral industry activities. This edition of the Minerals Yearbook presents the record on worldwide mineral industry performance during 1973. In addition to statistics, the volumes provide background information to help in interpreting the year's developments. The content of the individual volumes is as follows:

Volume I, Metals, Minerals, and Fuels, contains chapters on virtually all metallic, nonmetallic, and mineral fuel commodities important to the domestic economy. In addition, it includes a general review chapter on the mineral industries, a statistical summary, and a chapter on mining and quarrying trends.

Volume II, Area Reports: Domestic, contains chapters on the mineral industry of each of the 50 States, the U.S. island possessions in the Pacific Ocean and the Caribbean Sea, the Commonwealth of Puerto Rico, and the Canal Zone. This volume also has a statistical summary, identical to that in Volume I.

Volume III, Area Reports: International, contains the latest available mineral data on more than 130 foreign countries and discusses the importance of minerals to the economies of these nations. A separate chapter reviews minerals in general and their relationships to the world economy.

The Bureau of Mines continually strives to improve the value of the Yearbook for its users. Therefore, the constructive comments and suggestions of readers will be welcomed.

THOMAS V. FALKIE, *Director.*

Acknowledgments

Volume I, Metals, Minerals, and Fuels, of the Minerals Yearbook summarizes the significant data pertaining to mineral commodities obtained as a result of the mineral intelligence gathering activities of the divisions and offices of the Associate Directorate—Mineral and Materials Supply Demand Analysis.

The collection, compilation, and analysis of data on the domestic minerals and mineral fuel industries were performed by the staffs of the Divisions of Ferrous Metals, Nonferrous Metals, Nonmetallic Minerals, Coal, and Petroleum and Natural Gas. Statistical data were compiled by the statistical staffs of these Divisions from information supplied by mineral producers, processors, and users in response to production and consumption canvasses, and their voluntary response is gratefully acknowledged. The information obtained from individual firms by means of confidential surveys has been grouped to provide statistical aggregates. Data on individual firms are presented only if available from published or other nonconfidential sources or when permission of the companies has been granted. Other material appearing in this volume was obtained from the trade and technical press, industry contacts, and numerous other sources.

Statistics on U.S. imports and exports, world production, and foreign country trade were compiled in the Office of Technical Data Services. The foreign trade data for the United States were obtained from reports of the Bureau of the Census, U.S. Department of Commerce. World production and trade data came from numerous sources, including reports from the Foreign Service, U.S. Department of State.

The Office of Technical Data Services also provided general guidance on the preparation and coordination of the chapters in this volume and reviewed the manuscripts to insure statistical consistency among the tables, figures, and text, between this volume and other volumes, and between this edition and those of former years.

Acknowledgment is also particularly made of the splendid cooperation of the business press, trade associations, scientific journals, international organizations, and other Federal agencies that supplied information.

The Bureau of Mines has been assisted in collecting mine production data and the supporting information appearing in the Minerals Yearbook by numerous cooperating State agencies. These organizations are listed in the acknowledgment to Volume II.

ALBERT E. SCHRECK, *Editor-In-Chief*

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Review of the Mineral Industries

By Daniel E. Sullivan[1] and Nicholas G. Theofilos[2]

Although monetary and fiscal policies were less expansive in 1973 than in 1972, inflation was the major problem confronting the U.S. economy in 1973. Output expanded in all four quarters of the year, although the expansion was strongest in the first quarter. Income and employment increased and unemployment declined. The inflation was worsened by heavy demand and limited production of some food and fuel commodities.

Total output of the U.S. economy in 1973 as measured by the gross national product (GNP) grew 11.5%. Real GNP measured in 1958 dollars increased 5.9%, and inflation as measured by the implicit price deflator increased 5.3%. Greater inflation during 1973 caused the growth in GNP, in current dollars, to be larger than the 1972 growth of 9.4%, while in real 1958 dollars the growth in GNP was larger for 1972—6.1% as opposed to 5.9%. The increase in the implicit price deflator for 1972 was 3.2%. Gross private domestic investment and State and local purchases increased at a greater rate than did total GNP for 1973 as Federal purchases declined in real terms. The Federal Reserve Board (FRB) index of industrial production increased 9% during 1973.

Employment continued to increase during 1973. The unemployment rate averaged 4.9%, declining from the 5.6% average for 1972. Unemployment was near 5.0% at the beginning of the year, declined to a low of 4.6% in October, and returned to 4.8% in December. The labor force increased as it had during 1972, but in contrast to 1972 it did not dampen the decline in unemployment.

Prices increased more rapidly during 1973 than during any period since the Korean War. The overall consumer price index at 133.1 was 6.2% more than it was in 1972. Inflation in food prices proved to be a major problem area in 1973; the average was 14.5% above that for 1972. All nonfood commodities increased 3.4%. The 1973 wholesale price index increased to 135.5, 13.8% greater than the 1972 index. Farm product prices increased 41% and industrial commodities prices increased 8.5%. The 1973 implicit price deflator was 5.4% more than the 1972 figure, which was 3.2% greater than in 1971.

Monetary policy was much less expansive during 1973 than during the previous year. The FRB pursued a policy of active restraint in order to combat the severe inflation that had developed. During the year the money supply M_1, defined as currency plus demand deposits, grew 6.1% as opposed to a growth of 7.7% during 1972. M_2, defined as M_1 plus time deposits, grew at a rate of 8.8% as opposed to a growth of 10.9% during 1972. Both short- and long-term interest rates rose during 1973.

Federal fiscal policy was also less expansive during 1973 than during 1972. The deficit in the unified budget for 1973 was $14 billion, $11 billion less than had been projected the previous year. The reason for this was that outlays were slightly lower and receipts were considerably higher than expected. An even less expansive fiscal policy would have had more impact on the strong excess demand.

The present international monetary and trading system, with managed floating exchange rates, makes the measurement of the overall balance of payments less important. When exchange rates were fixed, one of the major functions of overall measures of balance of payments was to signal when an adjustment in the exchange

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rate was necessary. Early in 1973 the official price of gold rose from $38 to $42.22 per ounce. The price of gold on the private market was $112 at the end of 1973. Since the market price of gold has been much higher than the official price, governments have been reluctant to use it in international settlements. The U.S. basic balance during the first quarter of 1973 was in deficit by $0.9 billion, during the second quarter it was in deficit by $0.6 billion, and during the third it was in surplus by $2.5 billion.

Significant Federal actions of interest to the minerals sector included activities to slow inflation and meet the energy crisis in addition to the continuing mineral-related programs. During 1973 the anti-inflationary activities of the Economic Stabilization Act of 1971 were in effect. These activities included phase 2, phase 3, a 60-day freeze, and the implementation of phase 4. The energy crisis became more severe late in the year, leading to the introduction of a number of conservation and allocation programs. Mineral-related legislation approved by Congress and passed by the President during 1973 covered such areas as energy, the environment, water, public lands, the national stockpile, and import duties.

During 1973 research programs of the Bureau of Mines continued to emphasize the effective utilization of our national mineral and fuel resources so as to insure adequate mineral supplies without objectionable environmental, social, and occupational effects.

During 1973 energy use in the United States continued to rise. Domestic production of coal and crude petroleum declined while marketed production of natural gas increased slightly. Energy consumption increased in all major consuming sectors. This increased demand was met by increased imports and the drawdown of stocks. Fuel imports increased 33.1% over 1972 in spite of the Arab oil embargo in the fourth quarter.

The mining industry faced problems of minerals nationalism and environmental control during 1973. The industry was also affected by the strong inflation and increased demand that were prevalent in the economy as a whole. The industrial minerals continued their growth during 1973, but profits were lower. All mineral industries, and especially the high-energy-consuming industries, felt the effects of the energy shortage.

World trade increased strongly in 1973 despite monetary shifts and shortages in basic supplies. The international monetary system stood fast while allowing governments to make adjustments without disrupting international flows. Inflation was the major problem facing the world economy. Continued economic growth occurred in the developed countries.

SOURCES AND USES

ALL MINERALS

Production.—Domestic mineral production in 1973 was valued at $36.8 billion, a 14% increase from 1972. Production of all mineral groups increased at about the same rate except that of metals, which increased almost 20% during the year. In constant 1967 dollars the value of total mineral output increased only 5% from $25.7 billion in 1972 to $27.0 billion in 1973; metals and nonmetals increased about 8%, but mineral fuels increased less than 4%. Exports of primary minerals and mineral fuels increased 12% to $1.7 billion, and imports increased over 46% to $6.6 billion.

The Bureau of Mines total index of physical volume of mineral production (1967=100) increased a little more than 1% to 114.2 index points in 1973. The index for the average of all metals increased over 7% to 136.8. Within the metals group ferrous metals increased almost 18% and nonferrous metals increased less than 2%. In the nonferrous group, the base metals index increased over 2%, that for monetary metals declined almost 8%, and the other nonferrous index increased almost 2%. The index for the average of all nonmetals increased over 7%. The indexes for construction and for other nonmetals both increased at rates close to 9%; that for chemicals increased at a 3% rate. The overall index for fuels declined almost 2%, with the coal index declining less than 1%, and that for crude oil and natural gas declining less than 2%.

The FRB Index of Industrial Production (1967=100) increased almost 9% during 1973, from 115.2 to 125.2 index points. The

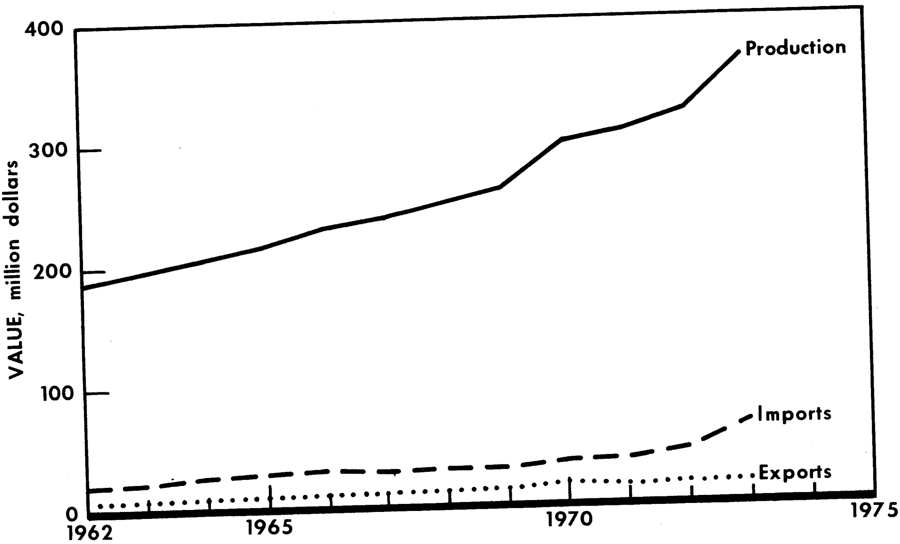

Figure 1.—Value of mineral production, exports, and imports.

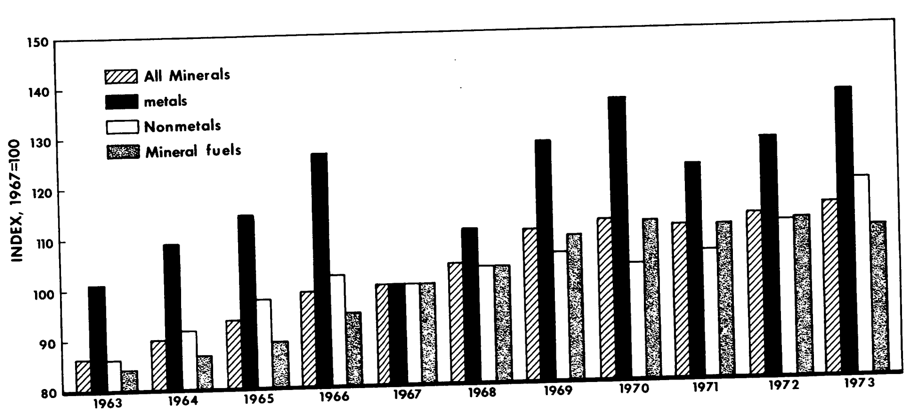

Figure 2.—Indexes of physical volume of mineral production in the United States, by group.

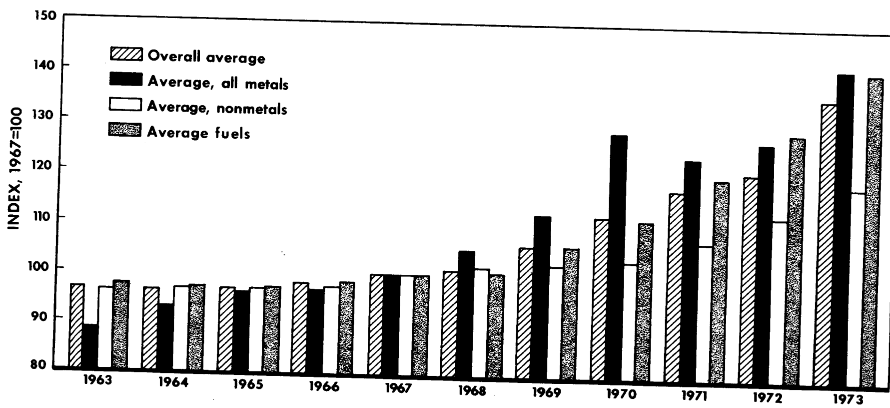

Figure 3.—Indexes of implicit unit value.

average for all mining increased 1.4 index points to 110.2, the metal and the stone and earth minerals indexes increased strongly, while the coal and the oil and gas indexes both decreased moderately. Strong increases in the primary metals, iron and steel, and nonferrous metals and products indexes ranged from 12% to 14%, and the clay, glass, and stone products index increased almost 10%.

The FRB monthly index of mining production (1967=100) was less than 109 index points for January and more than 110 points for February. It stayed between those two points for the next 4 months. In July it was 111 points, and it remained greater than 111 points until December when it was 110.7 points. The coal, oil, and gas index followed the same pattern although the individual coal index tended to be higher earlier in the year and lower late in the year, and the crude oil and natural gas index was highest both early and in the middle of the year. Metal, stone, and earth minerals remained between 116.0 and 117.0 index points for the first 5 months of the year, except in February when it reached 117.6 points. In June it hit a low of 111.8 index points and then rebounded, remaining above 120.0 index points for the final 5 months of the year.

Total net supply for most of the selected principal metals and nonmetals increased during 1972. The net supply of two-thirds of the selected ferrous metals increased. The largest increase was 50% in the net supply of tungsten, and the smallest was a 7% increase in the net supply of nickel. Iron ore, pig iron, and molybdenum all increased at rates in the teens while cobalt increased one-third. The net supply of steel ingot declined over 1%, chromite declined over 18%, and manganese declined over 13%. The patterns of change for the net supply of nonferrous metals reflected this same trend, with two commodities showing increases for each one showing a decline in net supply. The largest increase was over 27% for platinum-group metals and the smallest was less than 3% for cadmium. Copper, magnesium and zinc all had rates of increase in net supply at or above 4%. Rutile increased 9%, mercury over 21%, and uranium concentrate increased almost as much as platinum-group metals. The net supply of lead increased only a negligible amount. The net supplies of tin, aluminum, antimony, and ilmenite and slag decreased 11%, 7%, 6%, and 2% respectively. The net supply of all selected nonmetals except salt increased. The increases ranged from 19% for crude barite to 2% for finished fluorspar. Asbestos, bromine, clays, sand and gravel, and sulfur all increased about 8%; gypsum and phosphate rock increased at rates near 5%; all other increases were at rates in the teens. Common salt declined more than 2%.

Stocks and Government Stockpile.—During 1973 stocks of crude nonfuel minerals at primary producers, as reflected by the Bureau of Mines index (1967=100), declined substantially for all the selected metals and nonmetals. The overall index declined 22% to 110 index points and that for all metals declined 34%. The largest decline in the metals sector was a 51% drop in the index for other ferrous metal stocks. The iron ore index declined 26%, and the nonferrous index declined 14%. The nonmetals index declined almost 7%. Stocks of nonfuel minerals held by mineral manufacturers, consumers, and dealers as reflected by the Bureau index also declined, but not so strongly as those held by primary producers. The overall index declined almost 11%, with the index for all metals also declining by the same amount. The largest decline within the metals sector was in the other ferrous metals index which declined 27%, as was the case in the index of crude minerals held by primary producers. The stock index for iron declined 10%; those for base and other nonferrous metals both declined 9%. The index for nonmetals, excluding fuels, declined only 3%.

Producer stocks of bituminous coal and lignite decreased 14% in 1973, a sharp contrast to the large increase of the previous year. Coke stocks declined almost 60%. Stocks of carbon black and natural gasoline, plant condensates, and isopentane increased substantially. Total stocks of crude petroleum and petroleum products increased 5%, although those of most petroleum products except distillate fuel oil and the other products category declined. Distillate fuel oil stocks increased 27%, and the other products category increased 17%. Stocks of natural gas increased almost 11%.

From December 1972 to December 1973, the seasonally adjusted book value of product inventories increased for all selected industries except blast furnaces and steel mills. Petroleum and coal products increased 15.3% to $2,653 million as of December 1973. Stone, clay, and glass products increased 13.3% to $2,791 million. Total primary metals inventories decreased 3.6% to $9,314 because blast furnace and steel mills inventories decreased 11.8% to $4,645 million, while other primary metals inventories increased only 6.4% to $4,669 million. Total seasonally adjusted book value of inventories for selected mineral processing industries increased 2.3% to $14,421 million during 1973.

The national stockpile of strategic materials contained an important component of the Nation's mineral supply during 1973. Stockpile commodities of significant market value included aluminum, chromium, copper, lead, manganese, silver, tin, tungsten, and zinc.

Exports.—The total value of selected minerals and mineral products exported during 1973 increased 41% to $6,613 million. Exports in all sectors increased: Crude and scrap metals more than doubled; manufactured metals increased almost 60%; chemicals increased 44%; manufactured nonmetallic minerals increased 24%; and crude nonmetallic minerals increased 13%. The lowest rate of expansion occurred in exports of mineral energy resources and related products, which were up only 8% above those of 1972. Exports of only two mineral products declined; they were crude and partially refined petroleum, and uranium and thorium metals and alloys.

There were many changes in the geographical distribution pattern of selected mineral exports during 1973. Exports of sulfur and unroasted pyrites to other North American countries comprised 3% of the total exports of these commodities in 1972. in 1973 they increased to 42%. Exports to Asia of coke, coal, and briquets, including peat, declined from 34% to 2%. Exports of crude petroleum to North America increased to 29%, compared with none in 1972. Exports of iron and steel ingots and iron and steel rails shifted from North American to South American countries. Exports of silver, platinum, and platinum-group metals shifted in emphasis from Europe to Asia. Exports of zinc shifted from North America to South America and Asia. Exports of tin shifted from North America to South America; exports of uranium and thorium and their alloys to Europe remained steady while Asia received a larger share and North America a smaller share.

Imports.—The total value of selected mineral imports increased almost 38% to $16,047 million in 1973, with increases reported for all major categories. The most important and largest increase was in imports of mineral energy resources and related products, which increased 68% to $8,091 million. Within this group, coal, coke, and briquets (including peat) increased 2.6 times to $60 million, crude and partially refined petroleum increased 77% to $4,584 million, petroleum products except chemicals increased 72% to $2,954 million, and natural and manufactured gas imports increased 3.4% to $493 million. Imports of crude nonmetallic minerals increased 18.5% to $353 million. All imports within the nonmetallic group increased except those of sulfur and unroasted pyrites which decreased 11% to $15 million. Imports of crude and scrap metals increased 20% to $1,188 million. Within this group all minerals increased except nonferrous base metal ores and concentrates, which declined 1% to $466 million. Chemical imports increased 26% to $682 million. Within this group, only the mineral tar category declined. The manufactured nonmetallic minerals and the manufactured metals categories increased 35% and 14% respectively to $299 million and $5,435 million.

The percentage distribution of imports of principal minerals and mineral fuels and related products in 1973 by area of origin was generally stable with a few exceptions. One notable change was in imports of coal, coke, and briquets. In 1972, 92% of these imports came from North America and 1% from Europe. In 1973 the figures were 26% and 73% respectively. Other changes in import trade patterns were as follows: In 1972, 95% of phosphates came from North America, and none from Europe; in 1973 the figures were 78% and 11%; 14% of copper ores came from North America, 27% from South America, and 56% from Asia in 1972; in 1973 the figures were 48%, 35%, and 16% respectively; the distribution of imports of tantalum, molybdenum, and vanadium ores and concentrates shifted from South America to North America between 1972 and 1973; in 1972, 70% of the tin waste and scrap came from North America and none from South America; in 1973 the figures were 38% and 50% respectively; among platinum-group metals, ores, concentrates and wastes the import distribution pattern showed less from North America and more from Africa in 1973; North America supplied a smaller percent of the natural gas imported and South America a larger percent; some mercury import sources shifted from North America to Africa.

Consumption.—During 1973, consumption of most major mineral products increased substantially. Ferrous metals reflected this trend with the exception of manganese ore, consumption of which declined about 8%. Raw steel and iron ore consumption increased by 13% and 12%, respectively. Consumption of molybdenum increased by 25%. Consumption of all major nonferrous metals increased, with consumption of aluminum increasing less than 2% and that of copper increasing more than 7%. Consumption of antimony and silver increased by 28% and 30%, respectively while that of platinum-group metals increased 17%. Consumption of all other nonferrous metal commodities increased at rates between 2% and 5%.

Consumption of nonmetals increased for all major commodities except salt, which declined over 2%. Potash and crushed stone both increased more than 15%. Asbestos increased over 8% and phosphate rock increased less than 2%. All other major nonmetallic commodities increased at rates between 3% and 8%.

Total energy resource inputs in terms of British thermal units (Btu) increased almost 4% to 74,742 trillion Btu. Consumption of most mineral energy resources increased. That of anthracite coal remained constant and natural gas consumption declined less than 1%. Bituminous coal consumption increased almost 8%, and petroleum consumption increased over 5%.

Total net electricity generation increased 5% during 1973. Utilities increased almost 6% and industrial production declined almost 7%. Within the utilities, conventional fuel-burning plants increased 5%, hydropower declined less than 1%, and nuclear power consumption increased more than 54%.

ENERGY

Energy use in 1973 rose above the record high levels of 1972. As in other recent years, domestic energy raw material production did not match this increase; there were declines in the production of key fuels. This demand was met through a combination of increased imports of natural gas, crude oil, and petroleum products, increased production of natural gas, and a drawdown of stocks. This energy crisis was compounded late in the year when several Arab nations cut back crude oil production and curtailed shipments to the United States. However, petroleum imports had increased so strongly before the embargo that total imports of all fuels showed an increase for the year. The energy crises led to intensified efforts to encourage the discovery and development of new domestic sources of energy.

Production.—Total production of mineral energy resources and electricity from hydropower and nuclear power declined less than one-half of a percentage point in 1973 to 61,817 trillion Btu. All sources of energy production decreased except wet natural gas, which increased less than one-half of a percentage point, and nuclear power, which increased over 54% but remained less than 2% of total production. Anthracite declined almost 4%, bituminous coal and lignite and hydropower both declined less than 1%, and crude petroleum declined less than 3%.

Consumption.—U.S. energy consumption increased almost 4% in 1973 to 74,742 trillion Btu. Consumption of anthracite declined 4% in terms of Btu's. Consumption of bituminous coal and lignite increased 8% and that of petroleum 6%. Natural gas consumption declined less than 1% and natural gas liquids declined 1%. Consumption of electricity from hydropower declined less than 1%. Electric consumption from nuclear power increased 54%.

In 1973, the household and commercial sector received 40% of its energy input from natural gas; 38% from petroleum; 20% from electric utilities; and almost 2% from coal. The distribution of the inputs for industrial users was 46%, 25%, 11%, and 18% respectively. The transportation sector received 96% of its energy from petroleum. Energy inputs to electric utilities were from bituminous coal and lignite, 44%; natural gas, 19%; petroleum, 18%; hydropower, 15%; and nuclear power, 4%.

Coal.—The domestic supply of anthracite declined 4% in 1973 to 5.7 million tons; that for bituminous coal and lignite increased almost 8% to 556 million tons. Exports of anthracite declined almost 3%, and those of bituminous coal declined almost 6%. Imports of bituminous coal increased 170% to 127,000 short tons in 1973 after declining 64,000 short tons in 1972. Electric utilities used almost 70% of bituminous coal. The household and commercial sector was the largest user of anthracite.

Natural Gas.—The domestic supply of natural gas in 1973 was 22,245 billion cubic feet, almost 1% less than in 1972. Most supply components increased; the major factor in the decline in supply was the addition of 442 billion cubic feet to stocks. Domestic production increased less than 1%, exports decreased 1%, and imports increased 1%. Demand for natural gas declined in all consuming sectors except the largest, the industrial sector, which increased over 4% in 1973. The total demand for natural gas declined 1% in 1973.

Petroleum.—The domestic crude oil supply increased 6% to 4,537 million barrels in 1973. Domestic production declined almost 3%; exports more than tripled, but remained negligible; and imports increased almost 46% to 1,184 million barrels in spite of the Arab oil embargo. The domestic supply of refined petroleum products increased 5% to 6,298 million barrels. Demand for petroleum increased 5% to 5,578 million barrels. Transportation accounted for almost 53% of total domestic product demand.

Nuclear Energy.—In 1973 nuclear energy consumption was almost 54% greater than in 1972. In terms of Btu's it increased from just under 1% of total energy consumption in 1972 to 1.2% of the total in 1973. Research continued to be devoted to increasing the energy output from nuclear sources.

Hydropower.—Consumption of hydropower during 1973 was slightly less than in 1972. It provided less than 4% of the total energy consumption in the United States.

Other Energy.—The search for new sources of energy included the investigation of those sources which are only theoretical at this time, and others which will be significant only in the long term. Some of the types of energy being investigated were geothermal, oil shale, solar, wind, tidal, and biological (from organic wastes). Geothermal resources have received attention as a possible major source of energy. Geothermal resources are being developed rapidly, but the emphasis has been placed on developing known fields. Full development of geothermal energy will come only with the discovery of new fields and the technology they require.

EMPLOYMENT AND PRODUCTIVITY

Employment.—Employment in selected mineral industries increased during 1973, with total mining employment increasing over 4%. Employment in most sectors of the mining industries increased except that in other coal, and crude petroleum and natural gas fields each of which declined about 3%. Bituminous coal mining employment increased at a rate exceeding 10%, and oil and gas field services employment increased at a rate of almost 6%.

Minerals manufacturing employment increased 4% to 868,500 during 1972. All categories except total fuels and petroleum refining increased. Petroleum refining represents 78% of total fuels employment.

Hours and Earnings.—The hourly earnings in the mining sector continued to trend upward in 1973 with a 12.7% increase over 1972 earnings, a rate significantly higher than those of recent years. Weekly earnings increased 9.8% to $198.39 at an average of 44 hours per week. The highest hourly earnings in the mining sector were paid in the bituminous coal category, which increased by 40 cents to $5.74. The petroleum industry paid $4.69 per hour, slightly lower than the average for all mining. Hourly earnings for all metal mining increased almost 6.5% to $4.76, which is slightly more than the average for all mining, while average hours were slightly less than that for all mining. Hourly earnings for copper mining increased 5.6% to $4.88; for iron ore mining they increased 3.3% to $4.65. Average weekly hours for both copper and iron ore mining were close to the average for all metal mining. The nonmetallic mining and quarrying category paid the lowest hourly wages in the mining sector and also had the longest workweek with $4.18 and $47.1 hours, respectively.

Average weekly earnings in the manufacturing sector were $224.92, and average hourly earnings were $5.41, a 39-cent increase from the 1972 rate. The nonfuel manufacturing categories increased in weekly earnings by more than 9%, with the cement industry paying the most per week ($233.20), but the blast furnaces, and steel and rolling mills had the highest hourly earnings at $5.56. The fertilizer industry had the lowest weekly earnings ($156.66) and also the lowest hourly earnings. Average weekly earnings in the nonferrous smelting and refining industry increased 9.6%, and the hourly wage rate was $4.81.

Wages and Salaries.—In 1973 total wages and salaries for all industries increased substantially. The 10.3% increase was one percentage point above the 1972 increase. In the mining sector total wages and salaries also increased substantially but not as much as in 1972. The increase in manufacturing wages and salaries, which matched the increase in all industries in 1972, exceeded that for all industries in 1973. Average yearly earnings per full-time employee for all industries increased 5.8%, not as great as the 6.8% increase of 1972. In both mining and the manufacturing sectors, earnings increased more than those of all industries but were below the increases recorded in 1972.

Labor Turnover Rates.—The accession rate (hires and rehires) increased in 7 of the 10 selected mineral industries surveyed in 1973. The largest increase was in the copper ore category with seven employees being hired per thousand. The manufacturing, metal mining, and petroleum industries also increased their accession rate by four employees per thousand. The categories showing a decline in accession rates were the blast furnaces, steel and rolling mills, iron ores, and coal mining. The employee separation rate declined or remained the same in most of the selected mineral industries. Of the three categories showing increased separation rates, copper ores led with an increase of seven employees per thousand, followed by manufacturing, and petroleum refining and related industries. The layoff rate decreased in 1973 for all of the selected mineral industries except petroleum refining and related industries, which remained the same as in 1972.

Productivity.—Changes in labor productivity for selected mineral industries were mixed during 1972 (latest data available) according to the labor productivity indexes for selected minerals. Although the index for copper ore mined per employee and per production worker man-hour increased, the index per production worker declined slightly. The indexes of recoverable copper metal mined per employee, production worker, and production worker man-hour all declined during 1972. The indexes for crude iron ore mined and usable iron ore mined all increased significantly, as did those for refined petroleum. For bituminous coal and lignite the indexes showed small but mixed changes. The index of output per employee increased slightly and those for output per production worker and production worker man-hour showed small declines.

PRICES AND COSTS

Index of Average Unit Mine Value.—The index of average unit mine value and the index of implicit unit mine value, discussed below, give similar results but are developed by different methods. A detailed discussion of these indexes can be found in Bureau of Mines Information Circular 8275.[3] The total index of average unit mine value (1967=100) increased over 12% to 136.3 during 1973, following the rise in prices in the general economy. The index for ferrous metals increased at more than a third of the rate of increase of the total index, and the average for nonferrous metals increased more strongly than the rate of the total index. The base metals index grew at slightly less than the rate of increase for all nonferrous metals, but the index for monetary metals grew by more than 60%, and that for other nonferrous grew only slightly. Nonmetals increased at less than half the rate of increase in the total index. The construction index grew slightly more slowly than the index for all nonmetals, and the chemical, and other nonmetal indexes both grew at a faster rate. The fuels index grew more strongly than the total index. Coal increased at a slower rate and crude oil and natural gas grew at a faster rate than the total index.

Index of Implicit Unit Value.—The index of implicit unit value (1967=100) increased over 12% to 136.2 during 1973, reflecting the inflation of the economy as a whole. The index for ferrous metals increased at less than a third of the overall rate. The average for nonferrous increased at a greater rate than the overall index. Base metals reflected this growth, but the monetary metals index grew more than 50% and that for other nonferrous metals grew only slightly. Nonmetals increased at less than half the rate of increase for the overall index. The construction index grew slightly more slowly than the index for all nonmetals, and the chemical and other nonmetal indexes grew at a slightly faster rate. The fuels section increased almost as much as the overall index; within this group, coal grew less than the overall index, and crude oil and natural gas increased more strongly than the overall index.

Prices.—The wholesale price index for all commodities other than farm and food increased 7.7% during 1973. The index for all commodities, which include farm and food, increased at a rate of 13.8%, almost twice the rate of increase of the nonfarm index. The price indexes for various selected metals, minerals, and fuels either increased or remained unchanged. The index for metals and metal products increased 7.5%. Within this group the increases ranged from 2.3% for semifinished steel products to 54.4% for iron and steel scrap. Most other metal indexes increased moderately, with the exception of the nonferrous scrap index, which increased 44.2%; the primary metal refinery shapes, 20.3%; and

[3] Johnson, E. E. Index Numbers for the Mineral Industries. BuMines IC 8275, 1965, 85 pp.

nonferrous metals, 15.5%. Prices of nonmetallic mineral products increased 3.3%. Price changes in this group ranged from no change in phosphates and phosphate rock to a 6.5% increase in potassium sulfate. The price index for fuels and related products and power increased 22.7. Changes in this group ranged from a 6.4% increase in the electric power index to a 39.0% increase in the refined petroleum products price index. The coal price index increased 12.5%, and the crude petroleum index increased 10.7%.

Prices of most mineral energy resources increased substantially during 1973. The price of bituminous coal at merchant coke ovens increased almost 12%. Anthracite prices increased at a slower rate. The prices of petroleum and petroleum products all increased except for No. 6 residual fuel oil, maximum 1% sulfur, at Philadelphia, which declined almost 5%. The price of crude petroleum increased almost 15%. The average dealers' price for gasoline increased 10%. The average price for all gulf ports bunker C residual fuel oil increased 67%. The price of No. 2 distillate fuel oil at Philadelphia increased 14%, which is small when compared to the 104% increase in its price at all gulf ports. The average price of natural gas at the well increased 16%, but at the point of consumption it increased 7%.

The average cost of electrical energy in 1972 (latest data available) increased 0.1 cent to 1.8 cents per kilowatt-hour. Both residential market and commercial and industrial market costs increased 0.1 cent per kilowatt-hour, the former to 2.3 cents per kilowatt-hour and the latter to 1.5 cents per kilowatt-hour. Costs in all but two geographic areas increased. The exceptions were the East and West South-Central regions in which residential costs increased but the overall cost remained constant. Alaska and Hawaii remained the highest cost areas, and the East South-Central region remained the lowest cost area.

Principal Metal Mining Expenses.—The index of principal metal mining expenses (1967=100) showed the same pattern of increasing prices that was prevalent for the economy as a whole during 1973. The total index increased at a slightly higher rate than it did during 1972. The supply component increased at exactly the same rate as the total index, and the electrical energy and labor components increased at lower rates than the total index. The fuel components of the index increased almost 23%, which is more than three times the rate of increase of the total index.

Costs.—The 1973 index of relative labor costs and productivity generally reflected the inflationary aspects of the economy. For iron ore the index of labor cost per dollar of product was down significantly. This reflected the large increase in the index of value of product per man-period as the index of labor costs per unit of output declined slightly. For copper ore, while the index of labor costs per dollar of product declined slightly, both the index of value of product per man-period and the index of labor costs per unit of output increased significantly. In bituminous coal the index of labor costs per dollar of product increased slightly, and both the index of value of product per man-period and the index of labor costs per unit of output increased significantly. The indexes for petroleum for 1971 (latest data available) showed labor costs per dollar of product remaining unchanged, and the value of product per man-period and labor costs per unit of output both increasing.

The 1973 price indexes for mining construction and material handling machinery and equipment (1967=100) all showed increases over the equivalent 1972 index. The index for portable air compressors, which is the only index that declined in 1972, increased the least in 1973, 1.6%. The index for scrapers and graders increased the most, 9.4%.

INCOME AND INVESTMENT

National Income Generated.—In 1973 national income originating in all industries was $1,066 billion, a 12.6% increase over 1972. The mining industries income increased at a rate slightly above that for all industries to $9.4 billion. The rate of increase for metal mining income was almost double the rate for all industries. It reached the level of $1.2 billion. Income in coal mining increased to $2.4 billion, an 8% advance. The rate of increase in income for the crude petroleum and natural gas industries was just above the overall rate. It increased to $4.0 billion. Income originating in the mining and quarrying of nonmetallic minerals increased 15.8% to $1.8 billion. Income originating in the manufacturing sector increased 13.4% to $287.2 billion. The figure for the chemical and allied products industries increased 13.7% to $21.0 billion. The petroleum refining and related industries and the stone, clay, and glass products industries both had 14.3% increases in income, to $9.4 billion nad $9.9 billion respectively. Income originating in the primary metals industries increased 19.4% to $22.0 billion.

Profits and Dividends.—The average annual profit rate on shareholders' equity in all manufacturing industries increased during 1973 to 12.8%. Profit rates for all the selected mineral manufacturing industries increased significantly, and all but two industries (stone, clay, and glass products, and chemicals and allied products) increased at a greater rate than that for all manufacturing. One of these, chemicals and allied products, was the only mineral manufacturing industry with a greater average profit rate than that for all manufacturing. Profit rates in the primary metals industries, which were the lowest among the selected mineral manufacturing industries, increased more than 68%. Within this industry, the rates for primary iron and steel increased 58%, and those for primary nonferrous metals increased 83%. Profit rates in petroleum refining and related industries increased 33% to a rate of return of 11.6%.

Total dividends for primary metals increased in the same pattern as the profit rate, with primary nonferrous metals dividends increasing 46.8% to $543 million and dividends in the primary iron and steel industry increasing 21.3% to $559 million. Dividends for the stone, clay, and glass products, and for the chemicals and allied products industries increased at a slower rate than that for all manufacturing, which was 10.3%. Dividends in the petroleum refining and related industries were the largest among the selected mineral industries at almost $3.5 billion, a 3.8% increase over the previous year. Total dividends for all manufacturing in 1973 were almost $17.8 billion.

The total number of industrial and commercial failures in 1973 declined for the third consecutive year, although their current liabilities increased substantially. The total number of failures was 9,345, and the value of their liabilities reached almost $2.3 billion. There were 32 mining failures reported in 1973, 12 less than the figure for 1972, although current liabilities doubled from 1972 to the 1973 value of $23.9 million. In the manufacturing sector the number of failures declined in 1973, as did the current liabilities.

New Plant and Equipment.—New plant and equipment expenditures by mining and selected mineral manufacturing industries increased substantially in 1972. The figure for mining firms increased 14.0% to $2.76 billion; that for all manufacturing firms increased 21.2% to $38 billion. Expenditures increased for all of the selected mineral manufacturing firms. Primary nonferrous metals expenditures increased 42.4%, the largest increase; the smallest increase was a 3.0% increase in the expenditures of the petroleum and coal products industries.

Estimates of plant and equipment expenditures of foreign affiliates of U.S. companies in mining and smelting were revised back to 1966. Details may be found on page 19 of the December 1973 Survey of Current Business. Expenditures in mining and smelting increased 1% in 1973 to $1,261 million. Expenditures in Canada and Europe declined substantially, 26% for the former and 40% for the latter. Latin American expenditures increased over 7%, and those for all other areas increased almost 53% to $537 million. Expenditures in petroleum increased almost 16% to $6,180 million. All reporting areas except Latin America showed gains. The manufacturing sector showed gains in expenditures of almost 9% to a value of $7,743, with increases in all geographic areas.

Issues of Mining Securities.—Estimated gross proceeds of new securities offered by extractive industries totaled $1,073 million in 1973, compared with $2,010 million in 1972. Common stock accounted for 77.5% of the proceeds, preferred stock for 0.9%, and bonds for 21.6%.

Foreign Investment.—In 1972 direct private investment by U.S. companies abroad increased 9% to $94.0 billion (latest data available). The increase in the petroleum sector was also 9%; therefore, as a percent of the total, investments in the petroleum sector remained unchanged. The developed countries received $14.2 billion of the petroleum industry investment, while the developing countries received $9.9 billion. The book value of Canadian petroleum affiliates gained $162 million, compared with $327 million in 1972. The value of investments in European petroleum industries increased $800 million to $7.0 billion, the highest of all categories. Investment in Europe for all U.S. industries also increased. The Latin American countries' share of U.S. investment at the end of 1972 was $16.6 billion, compared with $15.8 billion in the beginning of the year. Investment for all industries was the lowest in the Middle East. Japan received the lowest investment in the petroleum sector, $796 million.

U.S. direct investments in foreign mining increased $411 million to $7.13 billion during 1972 (latest data available). Net capital outflows declined to $411 million. Reinvested earnings increased from $26 million in 1971 to $34 million in 1972. The developed countries again accounted for more than 60% of U.S. direct investments.

The value of foreign direct investments in the United States as a whole and in the U.S. petroleum sector continued to increase through 1972 (latest data available). Total foreign direct investments increased 5% to $14.4 billion, and in the petroleum sector the figure increased 4% to $3.2 billion.

TRANSPORTATION

The total quantity of selected minerals and mineral energy products transported by rail and water in the United States increased in 1972 (latest data available) but not at a rate as great as that for all commodities. Rail transportation of mineral products increased 2.2%, and water transportation increased 3.1%. More metals and minerals except fuels were transported by rail than water; however, for mineral energy resources and related products, the reverse was true. Total mineral products accounted for 56.2% of all commodities transported by rail and 83.4% of all commodities transported by water.

The quantity of metals and minerals except fuels transported by rail decreased by 1.1% to 396.5 million short tons. Iron ore and concentrates, iron and steel ingot, plates, rods, bars, tubing and other primary products, sand and gravel, crushed and broken stone, and phosphate rock were the largest users of rail transport in volume terms. Rail transport of most ferrous metals declined during 1972, and that of most nonferrous metals and nonmetals increased.

The quantity of metals and minerals except fuels transported by water increased 2.5% during 1972. Iron ore and concentrates and sand, gravel, and stone continued to be the two largest commodities transported by water in volume terms.

Mineral energy resources transported by rail increased 5.5% to 418 million short tons during 1972. Shipments of bituminous coal and lignite accounted for almost 89% of the total selected mineral energy resources and related products transported by rail.

The total volume of selected mineral energy resources and related products transported by water increased 3.4% to 577 million short tons during 1972. Coal, crude petroleum, and residual fuel oil accounted for almost 62% of this total.

A total of 951,200 miles of gas pipeline existed in 1972 (latest data available), a 1.9% increase above that of 1971. Total petroleum pipeline mileage in 1971 (latest data available) as reported previously was 219,000 miles. The total petroleum pipeline mileage reported was distributed among the following: Crude and gathering systems in field operations, 33%; large size crude trunklines, 34%; and petroleum product pipelines that extend from refineries to extraction terminals, 33%.

RESEARCH ACTIVITIES

Total expenditures for research and development activities for all industries were $19.5 billion during 1972 (latest data available). This was an increase of 6% over the $18.4 billion expended during 1971. Company expenditures increased almost 5% to

$11.2 billion, and expenditures by the Government increased almost 8% to $8.3 billion. Research and development in petroleum refining and extraction continued to decline, reaching $475 million during 1972. The great bulk of these expenditures was financed by private funds. Research and development expenditures in the chemical and allied products industries increased to $1.9 billion in 1972. Most of these expenditures also were privately financed.

Bureau of Mines.—Research activities of the Bureau were directed toward facilitating the efficient use of our natural mineral and fuel resources so as to insure adequate mineral supplies without objectionable environmental, social, and occupational effects. Bureau research concentrated on the following areas: Mining, metallurgy, resource recovery and pollution abatement, coal, petroleum, oil shale, economics, health and safety, explosives, and helium.

Bureau of Mines funding obligations for mining and mineral research and development were $77.50 million during fiscal year 1973, 9.3% more than for fiscal year 1972. Funds for applied research increased to $34.6 million, 44.6% of the total. Funds for basic research fell to $6.8 million, 8.9% of the total, and funds for development increased to $36.1 million, 46.5% of the total. Obligations for fiscal year 1974 were estimated to increase more than 16% to $90.1 million. Most of this increase was in funds for applied research. Bureau of Mines obligations for total research were $41.5 million for fiscal year 1973, a 2% increase above that of 1972. Funds for engineering sciences were $30.5 million; the figure for physical sciences declined almost $1.3 million to $9.3 million, the figure for mathematical sciences was almost $0.6 million, and the figure for environmental sciences increased to $1.1 million. Bureau of Mines funding obligations for total research for fiscal year 1974 were increased more than 25% to $52.0 million. Funds for engineering sciences were estimated to increase almost 25%, and those for physical sciences about 15%; those for mathematical and environmental sciences were estimated to almost double. Highlights of the accomplishments of Bureau research programs, including work in progress, are as follows:

Mining.—Bureau research investigations in the area of ground control have successfully tested, under actual mine conditions, both direct-wired and radio frequency models of a gage to monitor deflections of the mine roof. These gages provide early warning of roof sag and sound an alarm when critical deformation is reached. A titanium rock bolt load cell was developed and field tested at four mines in conjunction with other research projects. Several inquiries were received from mines wishing to obtain the cells for their own use. An instrument manufacturer has begun preliminary arrangements to obtain a license to produce the cells commercially.

A study to correlate strength of laboratory and in situ oil shale pillars was conducted as a first step in developing design criteria for underground room-and-pillar mining of oil shale. The conclusions drawn thus far were (1) high-angle joints can severely decrease in situ pillar strength and (2) the strength of jointed oil shale pillars can be determined accurately from laboratory strength tests on model pillars containing joints oriented as in its in situ counterpart.

One of the most promising techniques for mine stabilization is to consolidate the backfill. Laboratory tests using large-scale model stopes demonstrated the feasibility of consolidating mill run tailings by electrokinetics. The technique has an attraction to the operator in that the entire tailings output of the mill can be constructively used underground. Conventional backfill practice requires desliming and disposal of the slime fraction in surface ponds or dams. Increasingly stringent regulations for surface disposal make underground utilization of the tailings an attractive alternative.

A mine test of a flexible tunnel liner was completed. An 8-foot-diameter corrugated aluminum liner was installed with a 2-foot thickness of sand backpacking in extremely heavy ground at the Burgin mine (Utah). After 11 months, the drift is still open and usable. In contrast, a section of the same drift supported by yieldable steel arches was rehabilitated, but the steel arches have now failed a second time and that section of the drift has been abandoned.

An elastic-plastic, finite element analysis showing that a hydraulic backfill can effectively decrease stope closure and reduce pillar stress has been verified by field measurements in operating stopes. This better quality, higher modulus fill could permit removal of greater quantities of ore from the pillar area before a pillar rock-burst situation develops.

A preliminary experiment on the use of chemical explosives in vertical blast holes to fracture ground for in situ leaching of a shallow copper oxide ore body was successfully completed. The fractures were qualitatively judged adequate from the standpoint of creating permeability for leaching fluids. The encouraging results of this experiment have led to a cooperative agreement for further work at an operating mine in Arizona.

A study to determine the economics of using a large-diameter (12- to 24-inch) void hole in a burn cut and determine the influence of void hole diameter on fragmentation efficiency, depth of round pulled, and placement of the muckpile was begun. The first series of experiments were conducted in an underground copper mine and utilized a specially designed horizontal rotary drill to bore 12¼-inch-diameter holes. Several holes of this diameter were bored to a depth of 14 feet, and adjacent blastholes were fired to determine the correct burden and spacing. Using these results, a 50 foot-long, 12¼-inch hole was then bored and a 10- by 20-foot heading driven for this distance with excellent results in terms of blast efficiency and size distribution and placement of the muckpile. An advance of "pull" of 18 feet per blast round was achieved, which is approximately double the average advance previously attained in this mine using V-cuts.

High-pressure water jet cutting tests were made in conglomerate copper rock blocks over a broad range of pressures, standoff distances, and traverse speeds. Tests were conducted over a pressure range from 10,000 to 30,000 pounds per square inch. Under optimum conditions, depths of cut exceeding ¾ inch were obtained. Supplementary tests have shown that total energy requirements can be substantially reduced when mechanical action is used to augment the action of the water jets.

To eliminate problems of past mining activities, research efforts contained on subsidence control, controlling coal mine fires and burning coal refuse banks, utilizing coal mine refuse, and stabilizing and vegetating areas damaged by various types of past coal mining and processing activities. During the year four underground and/or outcrop coal mine fires on public and private lands were controlled, resulting in the conservation and protection of about 15 million tons of coal reserves.

Metallurgy.—The general objective of the metallurgy program was to provide, through research and development, the scientific and technical information necessary to encourage and stimulate the nonfuel minerals industry to make advancements in technology. During the year, industry frequently acknowledged its utilization of many of the Bureau's past research accomplishments in areas of metallic and nonmetallic minerals recovery as well as the production of improved metals, alloys, and ceramics.

The Bureau's program to demonstrate and evaluate processes for recovery of alumina from domestic nonbauxitic resources made excellent progress during the year. The first phase of the program, a miniplant for nitric acid leaching, was designed, installed, and successfully operated. Started in August 1973, the facility was capable of treating 60 pounds of calcined clay per hour. Representatives from industry attended the first full-scale demonstration of the miniplant in which the validity of the general flowsheet, and the chemistry of the process was shown. Invitations were also extended to the aluminum industry to participate in a 3-year program on a cost-sharing basis in order to accelerate the effort. To date, eight companies have indicated a willingness to enter the program starting in July 1974. Following the nitric acid evaluation, further evaluations are planned on hydrochloric acid, sulfurous acid, and lime-soda sinter processes. A significant new development in this program was the discovery that aluminum nitrate can be converted to the oxide using a fused-salt bath. The high heat transfer efficiency of the bath over proposed fluid bed schemes offers a significant energy and economic advantage as well as the means for effective recovery of reusable nitric acid.

Because of a pending worldwide shortage of rutile, considerable attention was given to developing methods for using domestic ilmenite to make feed material suitable for pigment-grade titania and titanium. The Bureau demonstrated a method to treat domestic ilmenite, including massive rock-type ores, using smelting and mineral synthesis techniques to yield high purity rutile. This method was applied successfully to both Idaho (33% TiO_2) and New York (45% TiO_2) ilmenites, to obtain 96% TiO_2 material, comparable to natural rutile in size, bulk density, purity, and response to chlorination. In another process, carbiding of calcium titanates and ilmenites after removal of iron was successfully achieved by adding lime and carbon to low-iron slags at elevated temperatures. The furnace product contained up to 70% Ti, 2.4% Fe, 24% C, and 0.7% SiO_2, which can be successfully converted to titanium tetrachloride with over 95% of the titanium in the feed converted to high purity titanium tetrachloride. Smelting with soda ash, in another process, demonstrated significant cost savings performance improvements, compared with using sodium borate as the flux.

The U.S. imports 90% of the ore needed to produce primary nickel. Research was started on developing the technology needed to utilize submarginal laterite deposits near the California-Oregon border and the nickel-copper deposits in Minnesota. The laterite process involved (1) carbon monoxide reduction, (2) multiple-stage oxidizing leach of reduced material, (3) extraction of nickel from solution, (4) extraction of cobalt from the raffinate, (5) magnesium removal by ion exchange, (6) recycling the solution back to the leach step, (7) stripping nickel from the solvent, and (8) electrolytic recovery of nickel. Recoveries from a laterite containing 1% nickel and 0.2% cobalt were 90% of the nickel and 83% of the cobalt, and no contaminating effluents were produced.

In fundamental flotation studies on galena, significant results were achieved in demonstrating the influence of surface oxidation products on electrochemical behavior. Results agreed with an earlier Bureau theory on the mechanism by which oxygen increases the flotability of sulfides using xanthate collectors, and the importance of semiconductor properties.

In continued research on gold and silver recovery, an improved cell for electrowinning gold from carbon strip solution was developed which promised notable improvements in convenience, cleanout time, and current continuity. Industry has expressed interest in using the Bureau cell, and adoption appears probable in the near future. In recent research, the carbon-in-pulp process was applied to silver ores, by moderately increasing the number of adsorption stages. Another promising low-cost carbon adsorption process was developed for recovering silver from mill tailings, in which 95% of the silver was selectively precipitated with sodium sulfide and removed by filtration. The effluent was passed through an activated-carbon column to collect the gold and residual silver, followed by newly developed alcohol-stripping techniques. An aqueous alkaline cyanide solution and methyl alcohol at ambient temperature, followed by elution with methyl alcohol distillate, stripped essentially all metals from the carbon. As a result of earlier research, pilot studies were initiated by a major gold producer for the recovery of gold from carbonaceous ore using the Bureau's electro-oxidation technique.

Because large reserves of native copper ores are too costly to mine and process by conventional methods, an in-place leaching method using ammonium carbonate was developed. In early leaching tests on 2% copper conglomerate ore with a 12-inch maximum rock size, about 57% of the copper was extracted in 60 days. In other Bureau research on copper heap leaching practices, major improvements in the recovery of copper and byproduct metals such as molybdenum, gold, and silver from some sulfide mine strip wastes were shown to be possible, by floating off the fines and using only the coarse rock. As much as 35% of the copper, 38% of the molybdenum, and 19% of the silver were recovered from the fines, while an additional 33% of the copper was recovered by leaching the coarse fraction. A total copper recovery of 68% was achieved, as compared to only 47% from leaching the ore, as received.

Considerable energy could be conserved and products improved if refractory-lined electric furnaces were used in place of water-wall cupolas for producing mineral wool from slags. A series of evaluation tests were conducted by the Bureau which demonstrated the superior performance of the high-alumina and basic refractories in resisting the molten slags. A demonstration test in a large electric arc furnace is being planned.

A new dicalcium silicate foundry mold

material suitable for both brass and steel castings was developed. This refractory material has the capability of self-decrepitation on cooling, permitting easy removal of the casting, and can also be reused. The mold material is produced by reacting $CaCO_3$ and SiO_2 at 1,400° C to form the gamma phase dicalcium silicate which changes in volume on cooling, causing the decrepitation. The beta phase portion of the material provides for its hydraulic setting capability in being made into a mold. More extensive foundry tests are planned.

Resource Recovery and Pollution Abatement.—The Bureau continued laboratory and pilot plant work to develop the citrate process for removing sulfur dioxide from waste gas. Construction was completed on phase 1 of the Bureau's citrate pilot plant at the Bunker Hill Co. lead smelter in Kellogg, Idaho. The citrate process is also being tested on stack gas from a coal-fired steam-generating station at the Pfizer, Inc., Vigo chemical plant, Terre Haute, Ind.

Extracting fertilizer from Florida phosphate minerals produces a slime, difficult to dewater, and requiring extensive holding ponds for storage. The Bureau's research, in cooperation with the Florida Phosphate Council, resulted in better characterization of the slime; data needed to develop an economical dewatering process. The amount of attapulgite in the slimes was highly variable and found to be a major factor in preventing easy dewatering. An anionic polyacrylamide was found to be an effective flocculating agent and is being investigated. Additions of tailing sand or use of sand as filter bed media also helped the dewatering. Another settling technique being developed moves screens slowly downward through vertical columns of slime, compacting the solids and collecting clear supernatant water above the screen.

Red muds from the Bayer alumina extraction process also pose a severe mineral waste disposal problem because of dewatering difficulties due to the extreme fineness of the suspended particles. In static settling tests, muds only changed from 14% to 20% solids in 48 hours; pH had no effect. In consolidation tests using vertical wick-drains, 34% solids resulted in 72 hours. The amount of liquid recovered was proportional to the number of drains, and the rate was dependent on the distance between drains. High-pressure filtration produced a 70% solids filter cake, compared to 50% for low-pressure filtration.

Several techniques for purifying waste waters from mineral- and metal-processing operations were developed. Methods for controlling troublesome calcic scale included an ion-exchange system for removing calcium sulfate and the use of trace quantities of chemical agents for preventing scale formation. Another ion-exchange technique used an inexpensive, naturally occurring zeolite for sorbing ammonia from waste water. Lignite was found to be an inexpensive scavenger for traces of mercury and cadmium remaining in waste water after conventional lime treatment. Selenium was precipitated from waste water using either metallic iron or zinc precipitants; testing on a larger scale is planned at a zinc refinery.

The Bureau's raw refuse pilot plant facility was significantly improved during the past year. High-quality glass was recovered from putrescibles by a multistep froth flotation process. High-quality aluminum was recovered from the glass by screening. Mixed heavy nonferrous metals were accumulated at the bottom of the jig bed. Reshredding and washing of the magnetic product, mostly tin cans, was simplified to prepare this material for detinning. In addition, combustible products obtained from the pilot plant were evaluated as potential fuel. On the average, refuse as received produced 5,000 Btu per pound and total combustibles, as recovered, produced 6,200 Btu per pound. A suitable method for recovery of aluminum from the secondary air classifier heavy product is being developed. Electrostatic separation showed considerable promise, producing concentrates of 80% to 85% aluminum with recoveries as high as 98%. High-frequency induction-repulsion also appeared promising with recoveries of up to 90%. Bureau-developed technology will be used extensively in constructing a new facility at Berlin, Conn., for the Connecticut Resource Recovery Authority.

The Bureau's incinerator residue recovery pilot plant was operated in support of the demonstration plant to be built at Lowell, Mass., by Raytheon Service Co.

Bureau junk automobile research has produced a new improved incinerator designed for smokeless burning. The prototype is capable of burning 10 flattened or 6.5 unflattened cars per hour. Currently, 26 similar junk auto incinerators are planned, under construction, or in operation. A much larger incinerator was built, based on Bureau design and capable of handling 1 railroad car or 20 scrap autos at a time. Equipment was also designed for separating the nonmagnetic reject of junk auto shredders into polyurethane foam, plastic, and metal concentrates. Further separation is possible to recover reusable materials.

The feasibility of preheating beds of ferrous scrap using exhaust gas from a basic oxygen furnace (BOF) was demonstrated. Using this technique, the 28% cold scrap maximum contained in the normal BOF metallic charge could be increased to 40% with heated scrap, a significant increase. This method recovers up to 50% of the energy contained in the offgases.

A new technique was developed for treating aluminum dross that eliminates the need for salt fluxes. Recoveries up to 100% of available metallic aluminum were obtained from samples held in an inert gas atmosphere at 740° C. This technique significantly reduces air contamination, eliminates slag formation, and yields aluminum recoveries equal to or greater than those obtained with salt fluxes. In addition, a hydrometallurgical process was developed for treating high-salt aluminum slags to recover fluxing salt, aluminum metal, and aluminum oxide. The process appears economically adapted to commercial application. A small demonstration plant will be operated for treating 50 to 100 pounds of slag per hour.

Other significant research was concerned with recovering metals and sands from foundry operations, silicon carbide from granite sawing, and metals from flue dust, mill scale, and industrial sludges.

Coal.—Coal research undertaken by the Bureau showed increased emphasis on the conversion of coal to low-ash, low-sulfur fuels through either gasification or liquefaction. At the same time continued effort was expended to improve the quality of the environment.

Work on the SYNTHANE pilot plant has progressed significantly. This Bureau-developed process gasifies any kind of coal with oxygen and steam to produce substitute natural gas. Following completion of pilot plant construction, operation should provide data essential to demonstrate the commercial feasibility of the process.

Favorable results were obtained in converting high-sulfur coal to low-sulfur oil by the SYNTHOIL process. In this process, coal slurried in recycle oil is propelled by rapid, turbulent flow of hydrogen through a fixed bed catalytic reactor at 840° F (450° C) at pressures up to 4,000 pounds per square inch. Using a cobalt molybdate catalyst, about 95% of the coal is transformed into an oil that is fluid at room temperature and is suitable for boiler plant fuel. Design of an 8-ton-per-day pilot plant is underway. In addition, a feasibility study of the process was completed by an outside engineering firm.

In coal-hydrogasification research, a preliminary test in the 10-pound-per-hour HYDRANE process developed unit (PDU) resulted in smooth operation of the first stage for 1½ hours. This was followed by a second 1½-hour run in the integrated first and second stages, during which test the moving-bed second stage operated at 1,290° F (700° C) and 1,035 pounds per square inch with a product gas containing 35% methane.

Research during the year on the Bureau's COSTEAM process showed that ash recovered from easily liquefied coals can effectively catalyze the liquefaction of more refractory (difficult to liquefy) coals.

During the year the final report on the design to be used in construction of the wood-to-oil pilot plant was completed. This pilot plant is to be erected at the Albany Metallurgy Research Center, and will be capable of converting 3 tons per day of wood chips to about 6 barrels of low-sulfur fuel oil.

In combustion research during the year, the combustion characteristics were determined for low-volatile (5%) chars prepared from Illinois and Utah coals. When the chars were fed to the 500 pound-per-hour pulverized-fuel-fired furnace at ambient temperature, supplemental fuel equivalent to 15% of the total thermal input was required to maintain stable flames. Preheating the primary air-char stream to 450°–500° F eliminated the supplemental fuel requirement.

In related coal combustion studies, construction was continued on the three-stage combustor, designed to produce low-ash, high-temperature gas suitable for use in open-cycle MHD power generation. This combustor could also be used as a source of low-Btu gas for firing boilers.

Testing of the stirred-fixed bed gas producer continued during the year, employing both caking and noncaking coals, again illustrating the versatility of this equipment. Preliminary results showed that when limestone chips were added to the coal feed, about one-half of the coal sulfur, which otherwise would appear as H_2S in the product gas, could be retained in the ash in the bed.

Treatment of dried lignite with oil was found to reduce reactivity of very-low-moisture lignite more effectively than similar treatment of lignite dried to a midmoisture content. The deactivation of dried low-rank coals to permit safe shipment and storage is a major objective in upgrading low-rank coals by drying. Such results may help establish commercial feasibility of the process.

Bureau research in coal preparation has resulted in the development of a two-stage pyrite flotation process, which in laboratory tests removed up to 90% of the pyrite contained in a Lower Freeport bed coal. Recently, the Bureau entered into a cooperative research program with a coal company to study the applicability of this process to a high-sulfur coal now being discarded as waste. Meanwhile, the two-stage pyrite flotation process is also being considered by a major steel company for commercial application to sulfur removal from Pittsburgh-bed coal.

Petroleum.—In what is planned to be a series of cooperative projects for increasing the production of domestic petroleum and natural gas, the Cities Service Oil Co. has signed a contract with the Bureau of Mines to perform a field demonstration of a micellar-polymer recovery method. Cities Service has chosen as the test site the El Dorado field, Butler County, in south-central Kansas. The field is typical of a depleted waterflood project that still contains oil that is unrecoverable by present technology. It is expected that nearly a year will be required to drill the pattern wells and prepare the field for the injection of the micellar fluids, and completion of the demonstration will take about 5 years.

A contract has been negotiated with the Sohio Petroleum Co. and others for use in in situ oil recovery field tests on 10 acres within a 320-acre tract they own in the Northwest Asphalt Ridge tar sand deposit.

Detailed characterization studies were initiated with the receipt of a sample of Utah Syncrude. This coal-derived oil, produced by the pyrolysis of Utah A-seam coal in the Coal-Oil-Energy Development (COED) process development unit at Princeton, N.J., has been hydrotreated to make a synthetic crude oil. This is the first in a series of samples to be analyzed in cooperation with the Office of Coal Research. The compositional data to be provided by the Bureau will be used to evaluate the oils in terms of ease of processing into quality fuels and to select the most appropriate plant operating conditions to produce such oils.

The Committee on Data for Science and Technology (CODATA) of the International Council of Scientific Unions (ICSU) recently issued a set of CODATA Recommended Key Values for Thermodynamics of 22 chemical species. The values are based on selections made at the U.S. National Bureau of Standards and the Institute for High Temperatures of the Academy of Sciences, U.S.S.R. Enthalpy-of-formation data provided by the Bureau of Mines were used in selecting the enthalpies of formation values for 6 of the 22 species.

In studies aimed toward developing an understanding of asphalt-aggregate adhesion, sulfoxides have been identified and quantitatively measured in the strongly adsorbed material found at the asphalt-aggregate interface. Sulfoxides are readily formed during the preparation of hot-plant road mixes from the sulfur compounds normally present in petroleum. They account for up to 25% of the strongly adsorbed materials and may be important to the water stability of the asphalt-aggregate bond. Moisture-induced damage in asphalt pavements is a major cause of road failure in many parts of the country.

Information recently has been released from both Government and industry sources showing that fuel economy of late-model autos has been reduced sharply in changing engines to control emissions. With fuel supply in deficit, the question is now asked—"Would economy be improved if emission controls were deactivated?" Although the Bureau has neither proposed nor endorsed such a course of action, its technical staff recognized a need for relevant data. To that end, fuel economy data were obtained on seven late-model cars, each tested both in standard configuration and with simple modifications that deactivated some emission controls. Results showed an average 9% gain in fuel economy. As expected, taken overall, emissions were increased—hydrocarbon up an average 30%; oxides-of-nitrogen, about 100%. Carbon monoxide emissions were relatively unchanged. It should be noted, however, that these percentage increases were from a low base and that at the higher values the emissions levels were, on the average, far below levels that were typical of precontrol autos. Detailed information on the test procedures and the results have been placed in an open file report.[4]

Particulate matter in the atmosphere can be a health hazard depending upon its composition, particle size, and other as yet poorly defined characteristics. In underground mines, diesel engines are a source of such airborne solids. Because of the possible health effects, the Bureau's experimental program on diesel exhausts included study of exhaust particulate. Results of experiments completed recently indicated that the mass loading of particulates in the exhaust from typical "clean" diesels may be as great as 100 times the allowable level in the working atmosphere. While ventilation air must be supplied to ensure adequate dilution of other toxic components in the exhaust, the amount required to purge the atmosphere of particulates may be even greater and thereby constitute an additional cost burden. In addition to the particulate matter, sulfuric acid droplets may be formed from the sulfur contained in the fuel. Results to date show that H_2SO_4 levels are very low except in the case where engines have been outfitted with oxidation catalysts. In this latter case, levels of sulfate have been found to be as great as 100 times the tolerable level. The sulfates are measured as an integral part of any particulate study.

The Higgins-Leighton waterflood prediction mathematical model and associated computer programs have been used extensively by industry since its publication by the Bureau several years ago. Using the model, an oil operator can select the operating conditions that will recover the highest possible percentage of the oil in the ground to meet the Nation's energy requirements. The model can also reveal inadequacies in the existing reservoir data.

Experimental work was recently completed on a study to determine how ambient temperature influences automotive emissions. Results showed that, in general, unburned hydrocarbon and carbon monoxide emissions were lowest when operating a vehicle within the 70°–80° F range. Amounts of those materials in the exhaust tended to increase with either lower or higher temperatures. The inference to be drawn is that measurements of emissions that are at the "normal" ambient test conditions may not provide a true measure of the emissions problem under real-world conditions. The data will provide a basis for judging (1) the need to adjust emissions estimates for existing ambient temperature, (2) the need for certification testing at more than one temperature, and (3) the need for some degree of control on the temperature-related degradation of emission under control system performance.

Oil Shale.—The oil shales of the Western United States represent one of the largest accumulations of hydrocarbon reserves in the world. Efforts have been undertaken to promote the development of these reserves. A new project was initiated on managing wastes and pollutants. The first problem to be undertaken—a study of the migration of fluids in connection with in situ oil shale processing—will utilize the in situ project already underway near Rock Springs, Wyo. An additional site in the northern Green River Basin was chosen at which underground water conditions will be established prior to any processing activity. Automatic data processing techniques are to be used to gather, store, process, and disseminate the mass of data required for a statistically sound project design.

Work continued at the Rock Springs site in preparation for an in situ combustion experiment at moderate depth. The zone to be retorted is being prepared by detonation of explosives injected into horizontal fractures created by hydraulic facturing, in contrast to a previous experiment at similar depth in which explosives were detonated in boreholes to establish the fracture system. A significant advance in fracturing research was obtained during the current site preparation by the creation of a system of three horizontal fractures separated by

[4] Eccleston, B. H. Emission Controls and Fuel Economy of Seven 1973 Vehicles. BuMines Open File Report, Feb. 15, 1974, 12 pages.

intervals of only about ten feet of shale at depths of 146 to 172 feet.

Experimentation in laboratory and pilot-size retorts simulating in situ conditions was continued to determine effects of operating variables, A series of six runs was completed in a 10-ton retort to study scale-up factors, using operating conditions duplicating previous runs in a 150-ton retort, and a new series was begun involving the addition of steam to the retort atmosphere. A small pressure retort was used to study effects of simulated overburden pressures in an inert atmosphere (nitrogen), and a report was prepared describing the effects on oil yield and quality. A similar series of experiments was begun using hydrogen as the retorting atmosphere. Preliminary results indicated that oil yields are higher than in the experiments with nitrogen.

Major contributions were made to the Department of the Interior Prototype Oil Shale Leasing Program, both through assistance in preparation of the Final Environmental Impact Statement and through rapid and timely assay of additional core samples from lease tracts and other sites in Colorado, Utah, and Wyoming. A report was published describing for the first time the oil shales in the Washakie Basin of Wyoming which includes two of the tracts offered for lease.[5] In addition to the Washakie Basin report, other reports on properties of oil shales relevant to their processing included one on shales at the Bureau's site near Green River, Wyo., one on the oil shales in Uintah County, Utah, one on the occurrence of aragonite in oil shale, one on a technique to estimate nahcolite and dawsonite from oil-yield data, and one on the thermal properties of two of the important oil shale minerals, dolomite and shortite.

Work directly concerned with oil shale processing resulted in a report on the kinetics of oil shale pyrolysis and three papers on shale oil processing. These papers covered the subjects of production of a shale oil Syncrude, characterization of this Syncrude, and catalytic denitrification of a shale gas oil.

Bench-scale research was conducted on gasification of shale oil or oil shale as an alternative or supplementary method of obtaining fuel values from oil shale by in situ processing. A series of single-stage hydrogasification experiments with in situ crude shale oil was completed, new equipment for two-stage hydrogasification was installed, and experiments were begun. Initial experiments obtained higher gas yields than with single-stage hydrogasification, and showed that over 97 weight-percent of the crude shale oil can be converted to gas with a high methane content.

Major progress was made under a lease agreement for an industry-sponsored project to develop and demonstrate a new aboveground retort design at the Bureau's Anvil Points facility in Colorado. The operating company, Development Engineering, Inc., took over the facility and completed construction of a pilot-size retort on which shakedown operations were begun with promising results. Installation of a semi-works-scale retort also neared completion.

Economic Analysis.—The Bureau's economic research program concentrated on analysis of the economic situation within the minerals sector as well as on how the mineral industries affect and are affected by conditions prevalent in the national and international economies. This research was designed to determine and interpret with accuracy the current situation so as to provide decisionmakers with adequate background material for their deliberations. The economic analysis program attempted to pinpoint pertinent data, and to develop the general methodology needed for such analysis. Major long-term research projects undertaken included the study and forecasting of demand, supply, and productivity; projections of economic data; financial analysis; mineral taxation; waste recycling; index numbers; input-output analysis; measures of economic activities stimulated by mineral industries; and the study and reporting of weekly price changes. Short-term projects, responding to the need to deal with rapidly changing economic conditions, were also a major part of the Bureau's economic research program. During 1973, short-term projects undertaken included oil shale leasing, alternatives for natural gas, a short-term energy forecasting model, an environmental impact statement on surface mining of coal, the impact of the Arab oil embargo on U.S. petroleum refineries, the impact of deficits of coal supplies on the U.S. economy, a solid waste

[5] Trudell, Lawrence G., Henry W. Roehler, and John Ward Smith. Geology of Eocene Rocks and Oil Yields of Green River Oil shales on Part of Kinney Rim, Washakie Basin, Wyoming. BuMines RI 7775, 1973, 151 pp.

management model for Spain, international mineral resources, minerals futures markets, projections of demand for stone and sand and gravel, energy's contribution to GNP, the value of primary minerals, and the impact of increased cost of gasoline on the demand for minerals.

Health and Safety.—Major efforts have been continued by the Bureau toward improving and securing the health and safety of miners. A portion of the research is summarized below.

The Bureau's pumpable roof bolt was field tested at the White Pine copper mine in Michigan. Because of the White Pine success, a contract was awarded for large-scale field demonstrations of the pumpable bolt. Under this contract a prototype pumpable roof-bolt machine was constructed, which would provide for remote-automatic installation of the bolts and incorporate the latest safety features developed under other program areas. Pumpable bolts will then be extensively tested in direct comparison to conventional bolting systems in at least two operating coal mines.

The Bureau's shortwall mining demonstration was initiated with the signing of a cooperative agreement with a coal operator and subsequent purchase of a shortwall roof support system. The props were delivered and installed, panels laid, and mining begun. The coal operator is to supply all of the remaining equipment. A rock mechanics study has been initiated to provide data from this demonstration which will aid other operators in determining the applicability of shortwall mining to their individual situations.

A comprehensive study of the behavior of the rock mass above an operating longwall was initiated. Fieldwork was conducted in cooperation with an operating coal company over a longwall mine in West Virginia. The data will be used to help operators and to further the understanding of subsidence.

Efforts to develop coatings to replace urethane foams for coal mines continued. A variety of sealants previously applied in the Ireland mine, Moundsville, W. Va., have been evaluated for their durability and effectiveness under severe conditions. Of the sealants tested, urethane foams (applied as a basis for comparison) and vermiculite cement sealants showed the least evidence of a sloughing or deterioration. More recently, about 15,000 square feet of roof and rib were coated with a magnesium oxsulfate sealant. Laboratory testing of this incombustible sealant indicated that it may be capable of replacing urethane foams in many instances. Field testing at the Ireland mine is designed to provide performance data for comparison with that of the sealants previously tested.

Techniques to strengthen rock in advance of mining by polymeric grouting were tested at a coal mine in West Virginia. Core sampling after mining had advanced showed that the polymeric material was completely cured, and that cracks as fine as 1 mil had been successfully bonded. The test showed that a friable coal mine roof can be successfully bonded into a more competent structure.

An evaluation determined that six brands of currently available wearable audiodosimeters met required response and overall accuracy requirements. A prototype time-resolved dosimeter, an instrument which records noise exposure as a function of time, was built and gave results that agreed well with data from a concurrent noise survey in a coal mine.

Tests of a trace gas technique that was developed for observing the course of ventilation air in metal and nonmetal mines showed it to be an excellent method for evaluating recirculation and the transit times of air and determining flow volumes and velocities, air exchange rates, and auxiliary fan effects in large airways with velocities too low for standard methods.

Four ignition suppression devices were being tested on continuous miners that are producing coal in gassy mines in West Virginia. The success of this effort will be evaluated after each of these machines has mined at least 20,000 tons of coal. Techniques have been developed for the construction of airtight and watertight seals from the surface through boreholes into the mine where out-of-control mine fires cannot be fought directly. The system was proved by the sealing of various passageways including a massive four-way intersection in a mine in West Virginia.

Work was completed on a contract to select the type of large mobile mining equipment most prone to fire, and to develop and demonstrate a fire sensing and control system for this equipment. The fire control system was successfully field-tested at two mines, each with adverse hot and cold temperatures, on a 100-ton-capacity ore truck. Fires set in the engine compartment and brake grid areas were automatically sensed and suppressed. Safety and management personnel at these mines were very interested in this piece of hardware, because it offered protection to the truck driver and protected a very expensive piece of equipment.

Meaningful progress toward acquisition of a multientry fire and explosion underground test facility was made during the year. The conventional mining system portion of the Inherently Safe Mining Systems (ISMS) demonstration phase was being conducted in a new single-section mine in Kentucky. Negotiations to acquire this site on a long-term basis, for fire and explosion research subsequent to the ISMS work, were in progress at yearend.

Preliminary results indicated that direct gas measurement on exploration cores can be used to estimate coalbed gas content and approximately predict methane emissions from a prospective mine. Monitoring of the vertical boreholes that have been drilled far in advance of mining has shown that dewatering of the coal is the key to successful degasification.

Respirable dust research was rapidly shifting to underground evaluation and demonstration. Dust suppression by water infusion was studied in three separate coal mines. In one of the sections significant respirable dust reduction was obtained, and the mining company has decided to modify a longwall section for routine application of the infusion procedure as part of the mining cycle. The remaining two companies have incorporated infusion into their dust control plans. An air curtain respiratory protective device that is part of the miner's hat was designed, developed, tested, and fabricated. Underground tests are to be conducted. A Stanford Research Institute optical particle counter developed under contract was evaluated in the laboratory. It has a linear response in the range of 1 to 40 milligrams per cubic meter and is easily reproducible and very reliable for relative measurements of dust concentrations. A new rapid infrared technique for the evaluation of alpha quartz in an individual field sample was developed. Comparison of this new technique with existing infrared and X-ray techniques showed positive correlation.

Two self-contained personal breathing apparatus have been developed to replace the currently used self-rescuers which are ineffective in atmospheres containing more than 1½% carbon monoxide and less than 16% oxygen. One apparatus has a 10-minute oxygen supply and the other a 1-hour supply. Both will protect the miner regardless of the toxic gases in the mine air. Both units have been tested and approved by the National Institute for Occupational Safety and Health.

Two improved communications methods for rescue teams have been developed to replace the heavy sound-powered telephone system which includes a handset and reel of wire. One method is a versatile, lightweight radio (walkie-talkie) that uses an unattached small-diameter wire between the radios for an antenna. The other method consists of a hand-free conduction microphone and ear speaker mounted on the rescuer's hardhat and a relatively lightweight attached wire between the fresh-air base and the rescue team.

Prototype electromagnetic hardware for locating trapped miners within 40 feet has been developed and tested successfully at four mines in West Virginia and Pennsylvania having overburdens as thick as 900 feet. The system consists of a miniature transmitter packaged inside the miner's cap lamp battery and operates from a small amount of excess energy in the battery. The signal is transmitted through the earth from a loop of wire connected to the transmitter and is detected by equipment carried on the ground surface or suspended from a helicopter.

Equipment and procedures were being developed to warn of unsafe conditions caused by high levels of CO, CO_2, and NO_x in diesel engine exhaust. Several types of monitors were investigated for each gas. Other efforts were directed specifically at reducing the levels of toxic emissions from diesel engines to the lowest levels practical without sacrificing engine performance.

Thirty-seven coating materials were tested in the laboratory for their ability to stop radon gas. Fifteen were successful in stopping 50% or more of the radon emanation from uranium ore specimens, and five of the best were selected for field testing. An instant working-level meter was developed by adapting and modifying an existing prototype instrument. This improved unit will sample, analyze, and indicate automatically the working level exposure resulting from the three different radon daughters and their ratios. The Bureau of Mines Dakota Experimental Uranium Mine near Grants, N. Mex., was used extensively for underground evaluation of laboratory-developed control technology and advanced instrumentation. A new experimental mine, located in Uravan, Colo., was leased following expiration of the Dakota mine contract. The new mine is being prepared for extensive use in 1974.

The toxic gases and vapors that may result from mine fires can present a major hazard to miners. A large number of brattice cloths, conveyor beltings, and hydraulic fluids have been approved in the past on the basis that they are fire retardant; however, their potential for toxic gas generation through decomposition has not been determined. Investigations were undertaken to determine and quantitatively analyze the toxic products produced upon thermal decomposition or combustion of these thermally unstable materials. Fourteen different items have been investigated using three different thermal test methods to determine the toxic compounds formed on a weight per weight basis, including gases and vapors.

A mine monitoring system has been developed, installed, and operated in a West Virginia coal mine. The system monitors a variety of environmental parameters at the intake and return of an air split. The data are telemetered to the surface, then sent via a leased telephone line to a remote computer where they are accumulated and analyzed. Results to date indicate that the monitoring system is suitable for use in underground mine environments and can be used to predict problems in the mine. Based upon experience from this and other mine monitoring systems that have been developed and are under evaluation, a new miniaturized mine monitoring and telemetry system has been developed by the Bureau. The system monitors four parameters (methane, ventilation, carbon monoxide, and temperature) and computes temperature rate of rise. The underground monitor station is housed in an enclosure approximately the size of a loud-speaker telephone and displays the results of the monitored parameters underground as well as telemetering this information to a small surface console.

A "Call Alert" system has been developed which consists of small pocket-sized receivers worn by roving miners that can be selectively activated from remote locations underground and on the surface. This system can be used to alert a specific individual that he is wanted on the loud-speaker telephone. The system is simple and inexpensive and requires only a small modification to the existing mine telephone circuit.

First generation mine lighting systems using circularly polarized, high-pressure sodium lamps were evaluated in high coal in an operating mine. The portable area system in both conventional and continuous miner sections and the machine-mounted system achieved the desired level of illumination in accordance with existing proposed standards, had very low maintenance, and in general were acceptable to mining personnel.

Efforts were continued to develop and test the feasibility of using protective canopies on low-coal electric face equipment. Adjustable canopies have been designed, fabricated, and installed on two shuttle cars, a cutter, a drill loader, and a roof bolter. Installation was made in two mines. The preliminary results appeared promising. Research continued to investigate the feasibility of using remote, semiautomatic or automatic controls on mining machines used in the face area and on shuttle cars. Various facets of these systems have been successfully demonstrated.

A contract was let in fiscal year 1972 to determine the adequacy of available circuit breakers for use on 300- to 600-volt direct current (v.d.c.) circuits. The existence of "molded case breakers" suitable for interrupting 300- and 600-v.d.c. service in underground coal mines has been demonstrated. Permissible quick-opening electrical enclosures with a built-in feature to lock and check the access cover have been developed. This new design will provide more expeditious access to components inside explosion-proof boxes for maintenance and inspection and still maintain the essential explosion-proof provisions of these boxes.

An automated prototype peristaltic conveyor was developed, and a number of coal slurry tests were made. The conveyor consists of air-actuated rubber valves connected in series. A slurry of ¼-inch by 0 coal with a concentration of 55% by weight was successfully conveyed; tests using larger coal sizes and greater concentrations have been unsuccessful to date. The peristaltic conveyor has potential for moving high-concentration slurries over short distances and for injecting solids into a pressurized continuous hydraulic transportation pipeline.

The primary technology transfer effort in 1973 was the active dissemination of research accomplishments through the mechanisms of Open Industry Briefings (OIB) and topic seminars. The Bureau held six Open Industry Briefings in conjunction with various mining associations across the United States. These briefings provided status reports to the mining industry on Bureau research programs such as methane control, respirable dust, fire explosion prevention, and others. Four seminars were also held by the Bureau during 1973. Seminars, unlike the OIB, dealt in much finer detail with the specifics of the Bureau's research accomplishments, including the engineering details of applying technologies of oil and gas well plugging, methane control, instrumentation for mine design, mine communications, and ground control aspects of coal mine design. These meetings, attended by representatives from the mining and associated industries, have in fact provided impetus for adoption of Bureau-developed research accomplishments. An additional effort of this type was the technology transfer exhibit at the 1973 coal show at which a large number of Bureau-developed devices were displayed. The first of a new publication series, *Technology News,* was also being prepared for distribution throughout the industry. The series will offer concise, definitive, application-oriented statements of accomplishments that have resulted from the research program and will provide timely information to potential technology users.

Explosives and Explosions.—The technical feasibility of the major objective of the explosive identification program was accomplished by successfully extracting a seven-element code from phosphor grains surviving detonations. However, raw phosphor grains were found to sensitize some explosives; suitable grain coatings are currently being explored to eliminate this effect.

Various sensitivity tests were conducted on a large number of different blasting agents used in metal and nonmetal mining. Ammonium nitrate-fuel oil (AN-FO) mixtures using four types of Canadian AN were found to exhibit unusually high sensitivities; the most sensitive mix had a 50% initiation velocity (V_{50}) of 640 meters per second and was cap sensitive.

The feasibility of formulating a water-based explosive without the use of flaked aluminum or explosive sensitizers was demonstrated.

Seven experimental detonators with different casing material were evaluated for incendivity in 8% natural gas-air. The least incendive material was nickel-clad steel, which was found to be slightly less incendive than copper and could serve as a substitute in times of copper scarcity.

In research on hazardous materials, the effort to improve the drop weight, static spark, and friction sensitivity tests was continued. It was found that primary explosives like lead azide could be initiated with the same spark stimulus in an N_2 atmosphere as in air, while substances like powdered tetryl which appear to deflagrate could not be initiated in an N_2 atmosphere at spark energies several orders of magnitude higher than that observed in air trials. Laser ignition of explosives was also demonstrated.

Quantitative luminosity measurements on the light generated by water-based permissible explosives established that they generate a larger amount of visible radiation than conventional permissible explosives; however, this is not reflected in an increase in their relative incendivities in natural gas-coal dust-air mixtures. An empirical ignition probability model which related explosive chemical composition and relative incendivity was developed during extensive computer studies of incendivity test results.

Helium.—The Bureau of Mines has over the years maintained at least a minimum research effort in the areas of helium production and analytical methods and techniques relating to helium in natural gas and the impurities in the purified helium. During 1973, laboratory work continued in this vein with the development of a highly sensitive analytical procedure which accurately detects the helium-3 content in helium-4 in the parts-per-billion range.

In conjunction with this development, the Bureau completed a laboratory project which lowers the helium-3 content of helium-4 from the normal level of about

250 parts per billion to below 20 parts per billion. This special helium-4 has application in the developing field of helium-cooled nuclear reactors. Helium-3 molecules circulating around a reactor core, along with the normal helium-4, are bombarded with neutrons. As a result, radioactive tritium is formed. When the helium-3 is removed from helium-4, the potentially troublesome radioactive source is removed. Helium-4 leaves no such radioactive product.

LEGISLATION AND GOVERNMENT PROGRAMS

Significant Federal activities in the minerals sector included special actions to fight inflation and to meet the energy crisis as well as continuing programs dealing with the environment, water, public land, national stockpile, and tariffs.

Actions taken under the Economic Stabilization Act of 1971 included shifting from phase 2 (which was in effect during all of 1972) to phase 3 in January 1973. Phase 3 was intended to be a step toward the eventual end of price controls. It involved the self-administration of a modified version of the general standards of phase 2. Prenotification for price increases was modified and eliminated for wage increases. Fewer firms were required to report, and rents were added to the phase 2 exemptions to the price standards. The rate of inflation during the first 5 months of 1973 remained disappointingly high, with few signs that it would slow later in the year. On June 13 the President announced a new 60-day freeze to be followed by phase 4. Phase 4 combined some aspects of both phase 2 and phase 3 although in some cases it was stricter than phase 2. Phase 4 remained in effect for the remainder of 1973. Inflation continued to be a major problem during 1973 in spite of the price controls.

During 1973 the United States was faced with an energy crisis. Shortages of petroleum late in the year following the decision by several Arab nations to cut back crude oil production and to curtail shipments to the United States impelled the Federal Government to attempt to conserve and allocate energy supplies to insure the availability of fuels for critical uses. A long-range outcome of the energy crisis was "Project Independence" which was designed to ensure an expansion of domestic energy production so that the economy would no longer face disruption or the threat of disruption from sudden curtailment of vital energy supplies.

Legislation affecting the mineral sector and approved during the first session of the 93d Congress covered such areas as energy, the environment, water, public lands, the national stockpile, and duties. Energy was the concern of a number of laws. P.L. 93–159 gave the President the authority to deal with the energy shortages. Two other laws dealt with energy conservation. P.L. 93–182 put the country on daylight saving time year-round. P.L. 93–239, which was passed during 1973 but not signed by the President until early 1974, established a maximum 55-mph national speed limit. P.L. 93–88 amended the Euratom Cooperation Act to increase the amount of contained uranium 235 which the U.S. Atomic Energy Commission is authorized to transfer to the European Atomic Energy Community. Several laws concerning the environment were passed. A number supplied funding to continuing environmental programs; others were concerned with international environmental agreements. P.L. 93–207 extended and expanded the Federal Water Pollution Control Act. Other measures of interest to the minerals sector included laws for disposing of the zinc, copper, silicon carbide, molybdenum, and aluminum in the national stockpiles, and laws which extended the suspension of duties on certain copper, certain kinds of metal scrap, and manganese ore. A listing of mineral related Federal legislation signed into law during 1973 follows:

Public Law (P.L.)	Description	Signed into law
Energy:		
P.L. 93–88.	—To increase enriched uranium ceiling under Euratom Cooperation Act.	Aug. 14
P.L. 93–159.	—Proposing more precise and definite authority for the President to deal with emergency shortages of petroleum products.	Nov. 27
P.L. 93–182.	—Providing for use of daylight saving time on a year-round basis until April 1975.	Dec. 15
Environmental quality:		
P.L. 93–14.	—Authorizing funds for the administration of the Solid Waste Disposal Act for fiscal year 1974.	Apr. 9

Public Law (P.L.) Description	Signed into law
Environmental quality—Continued	
P.L. 93-15.—Authorizing funds for the administration of the Clean Air Act for fiscal year 1974.	Apr. 9
P.L. 93-36.—Authorizing funds for the Office of Environment Quality for fiscal years 1974 and 1975.	May 18
P.L. 93-119.—Implementing the 1969 and 1971 amendments to the International Convention for the Prevention of the Pollution of the Sea by oil.	Oct. 4
P.L. 93-188.—Providing for U.S. participation in the United Nations environmental program.	Dec. 15
P.L. 93-201.—Proposing removal of certain restrictions on the transportation of dry bulk commodities by water carriers.	Dec. 27
Water resources:	
P.L. 93-51.—Authorizing funds for the saline water conversion program for fiscal year 1974.	July 1
P.L. 93-207.—Proposed Federal Water Pollution Control Act Amendments.	Dec. 28
Public lands:	
P.L. 93-153.—To establish a Federal policy granting rights-of-way across Federal lands.	Nov. 16
P.L. 93-184.—Providing for the conveyance of certain mineral rights in and under lands in Onslow County, N.C.	Dec. 15
National stockpile:	
P.L. 93-212.—Authorizing disposal of zinc from the national stockpile.	Dec. 28
P.L. 93-214.—Authorizing disposal of copper from the national stockpile and supplemental stockpile.	Dec. 28
P.L. 93-216.—Authorizing disposal of silicon carbide from the national stockpile.	Dec. 28
P.L. 93-219.—Authorizing disposal of molybdenum from the national stockpile.	Dec. 28
P.L. 93-220.—Authorizing disposal of aluminum from the national stockpile.	Dec. 28
Tariffs and duties:	
P.L. 93-77.—Extending to June 30, 1974, the suspension of duty on certain copper.	July 30
P.L. 93-78.—Extending to June 30, 1975, exiting suspension of duty on certain kinds of metal scrap.	July 30
P.L. 93-99.—Extending until July 1, 1976, the existing suspension of duty on manganese ore.	Aug. 16
Miscellaneous:	
P.L. 93-183.—Naming the Geological Survey National Center under construction in Reston, Va., as the "John Wesley Powell Federal Building."	Dec. 15

The acquisition cost of strategic materials in Government inventories totaled $5.2 billion with a market value of $7.4 billion as of December 31, 1973. Materials in these Government inventories with a market value of $6.5 billion, which is 88% of the total market value on hand, were considered in excess of stockpile needs. In calendar year 1973 the Government disposed of $953 million worth of mineral commodities, a more than threefold increase from the 1972 figure.

Sales of aluminum had a value greater than $400 million and comprised more than 40% of the total minerals sold. Major mineral stockpile items sold during the year with a sales value of at least $50 million each included lead, magnesium, metallurgical manganese, ferro-high-carbon manganese, tin, and zinc. Cobalt had a value greater than $20 million, and magnesium sales were greater than $40 million.

WORLD REVIEW

World Economy.—International trade and investment grew significantly during 1973 in spite of the adverse effects of inflation, wide fluctuations in exchange rates, large capital flows, capacity limitations, crop failures, and cutbacks in oil production by major producers. The international monetary system was maintained while allowing governments to deal with their economic problems without disrupting international trade and investment flows. The international economic system was strengthened by mutual efforts to arrive at solutions to common problems.

Inflation was the major problem facing the world economy during 1973. There were large increases in the prices of basic foods and processed materials. Some measures taken by governments in response to the inflation had the effect of shifting the inflation to other countries, but in general tensions created by such policies were eased.

Continuing economic growth was the typical pattern for the developed countries. Industrial production grew at a rate greater than 10% for the countries of the Organization for Economic Co-Operation and Development, although those located in Europe grew at a rate just over 8%.

World Production.—The United Nations (UN) indexes of world mineral industry production (1963=100) for the extractive industries increased 9 index points to 166 for 1973. The metal mining index increased 8 points to 158, the coal index increased 2 points to 104, and the crude petroleum and natural gas index increased 12 points to 202. The mineral processing industries indexes show a 17-point increase to 182 for base metals, a 15-point increase to 192 for the nonmetallic mineral products index, and a 26-point increase to 250 for the chemicals, petroleum and coal products index. Overall industrial production as measured by the UN index rose 17 points to 194 for 1973.

World Trade.—The value of world trade reached $412.4 billion in 1972, almost 19% greater than the value for 1971. The value of mineral commodities exports for 1972 was $83.4 billion, almost 14% greater than the previous year. The value of metals exports increased 11% in 1972 after declining 5% the previous year. Within this group, all ores, concentrate and scrap exports increased almost 7%, iron and steel exports increased almost 13%, and nonferrous metals exports increased almost 12%. Nonmetal exports were $2.9 billion, almost 14% greater than they were in 1971. World trade in mineral fuels reached $41.2 billion, 16% greater than it was in 1971.

World Prices.—Mineral commodity export price indexes (1963=100) increased in both the metal ores sector and the fuels sector. In 1973 metal ores increased by 27 index points and fuels by 45 points, reaching 161 and 188, respectively. Total minerals prices increased significantly in both developed and developing areas. Nonferrous base metal prices in developed areas increased by 38% while those of the developing areas increased by 57%.

Table 2.—Value of mineral production by group, 1967 constant dollars [1]

(Million dollars)

Mineral group	1969 Production	1969 Exports [2]	1969 Imports [2]	1970 Production	1970 Exports [2]	1970 Imports [2]	1971 Production	1971 Exports [2]	1971 Imports [2]
Metals and nonmetals except fuels:									
Nonmetals	5,624	222	491	5,712	225	551	6,058	226	573
Metals	3,333	246	1,094	3,928	322	1,249	3,403	192	1,047
Total [3]	8,957	467	1,586	9,640	547	1,799	9,461	418	1,620
Mineral fuels	17,965	632	1,428	20,152	1,120	1,567	21,247	1,020	2,076
Grand total [3]	26,921	1,099	3,014	29,792	1,667	3,366	30,708	1,438	3,696

Mineral group	1972 Production	1972 Exports [2]	1972 Imports [2]	1973 p Production	1973 p Exports [2]	1973 p Imports [2]
Metals and nonmetals except fuels:						
Nonmetals	r 6,482	152	646	7,413	280	768
Metals	r 3,642	r 247	988	4,362	253	1,080
Total [3]	r 10,124	r 399	1,634	11,775	533	1,849
Mineral fuels	r 22,061	r 1,108	2,856	25,012	1,155	4,720
Grand total [3]	r 32,185	r 1,508	4,490	36,788	1,688	6,569

r Revised. p Preliminary.
[1] For details, see the "Statistical Summary" chapter of this volume.
[2] Essentially unprocessed mineral raw material.
[3] Data may not add to totals shown because of independent rounding.

Table 2.—Value of mineral production by group, 1967 constant dollars [1]

(Million dollars)

Mineral group	1969	1970	1971	1972	1973 p
Metals and nonmetals except fuels:					
Nonmetals	5,498	5,535	5,646	5,762	6,250
Metals	2,965	3,052	2,742	2,861	3,074
Total	8,463	8,587	8,388	8,623	9,324
Mineral fuels	16,948	18,074	17,735	17,075	17,676
Grand total	25,411	26,661	26,123	25,698	27,000

p Preliminary.
[1] Value deflated by the index of implicit unit value.

Table 3.—Indexes of the physical volume of mineral production, by group and subgroup[1]

(1967=100)

	1969	1970	1971	1972	1973 p
METALS					
Ferrous	110.9	109.3	96.9	98.4	116.0
Nonferrous:					
Base	149.6	167.3	151.0	162.8	166.5
Monetary	115.5	123.9	r 110.6	102.7	94.5
Other	111.0	119.5	115.5	112.6	114.8
Average	141.7	157.4	143.0	151.1	153.6
Average, all metals	127.9	135.8	122.3	127.5	136.8
NONMETALS					
Construction	106.6	103.1	106.2	111.7	121.3
Chemical	101.4	103.1	101.9	108.7	112.0
Other	107.3	109.1	105.5	112.2	122.7
Average	105.5	103.4	105.2	111.0	119.3
FUELS					
Coal	100.9	108.3	98.9	105.9	105.1
Crude oil and natural gas	110.5	112.0	111.3	111.4	109.3
Average	109.1	111.7	109.7	111.2	109.3
Average, all minerals	110.1	112.1	109.9	112.7	114.2

p Preliminary. r Revised.
[1] Historical table of this series in Bureau of Mines Minerals Yearbook of 1971.

Table 4.—Federal Reserve Board indexes of industrial production, mining, and selected minerals and mineral fuels related industries

(1967=100)

	1969	1970	1971	1972	1973 p
Mining:					
Coal	101.1	105.7	99.8	104.2	103.6
Crude oil and natural gas:					
Crude oil	104.8	109.4	108.3	107.3	104.5
Gas and gas liquids: Average[1]	106.9	109.7	111.3	110.0	108.5
Average coal, oil, and gas	106.1	109.2	107.6	109.2	108.3
Metal	124.8	131.3	121.4	120.9	130.8
Stone and earth minerals	102.8	98.8	93.2	98.1	109.5
Average	111.7	112.0	104.6	107.3	118.1
Average mining	107.2	109.7	107.0	108.8	110.2
Industrial production:					
Primary metals	114.1	106.9	100.9	113.1	127.1
Iron and steel	113.0	105.3	96.6	107.1	121.6
Nonferrous metals and products	116.0	109.7	108.7	123.9	139.7
Clay, glass, and stone products	112.5	106.3	110.0	118.6	129.9
Average industrial production	110.7	106.7	106.8	115.2	125.2

p Preliminary.
[1] Includes oil and gas drilling.

Source: Federal Reserve System. Federal Reserve Bulletin. V. 59, No. 12, December 1973, pp. A60–61; Dec. 14, 1973 and Feb. 15, 1974.

Table 5.—Federal Reserve Board monthly indexes of mining production, seasonally adjusted

(1967=100)

Month	Total mining [1]		Coal, oil, gas		Coal		Crude oil and natural gas				Metal, stone, earth minerals		Metal mining		Stone and earth minerals	
							Total [2]		Crude oil							
	1972	1973	1972	1973	1972	1973	1972	1973	1972	1973	1972	1973	1972	1973	1972	1973
January	107.3	108.5	107.1	106.5	106.3	99.1	107.1	108.4	104.0	105.5	108.0	116.4	128.9	130.3	93.8	106.9
February	107.2	110.2	106.5	108.4	99.6	103.9	107.4	109.9	104.2	106.7	109.8	117.6	133.7	131.9	93.5	107.8
March	108.4	109.5	109.2	107.6	110.1	105.7	109.6	107.1	106.9	103.7	105.6	117.0	123.1	127.8	93.7	109.4
April	109.4	109.0	110.2	107.1	111.9	99.9	110.3	107.6	106.6	103.6	106.4	116.0	123.2	128.5	95.0	108.8
May	108.0	109.1	109.4	107.3	103.8	100.9	112.1	108.5	109.5	104.6	102.9	116.2	113.5	127.0	95.8	108.8
June	108.6	109.5	110.4	108.9	109.0	108.0	112.3	109.2	108.8	104.6	101.2	111.8	108.0	121.6	96.6	105.2
July	108.6	111.0	110.3	109.5	109.0	109.0	112.3	110.0	108.6	105.4	101.9	116.9	109.8	128.4	96.8	109.1
August	108.8	111.5	109.3	109.2	97.8	104.0	112.7	109.6	108.8	104.8	106.8	120.6	118.6	131.4	98.5	113.1
September	110.8	111.8	110.8	109.5	105.2	109.8	113.1	108.9	108.4	103.9	110.6	120.4	124.8	136.6	101.1	109.5
October	110.2	111.9	110.1	109.7	100.8	103.0	112.3	108.9	107.9	104.2	110.4	120.9	122.8	138.3	102.0	109.2
November	109.7	111.3	109.0	108.8	102.6	104.1	111.1	107.6	107.0	103.7	112.6	121.3	124.7	135.2	104.4	111.7
December	108.2	110.7	106.8	107.8	98.6	106.4	109.4	105.9	106.4	102.9	113.7	122.0	128.1	135.2	104.0	113.1
Average	108.8	p 110.2	109.2	p 108.3	104.2	p 103.6	110.9	p 108.4	107.3	p 104.5	107.3	p 118.1	120.9	p 130.8	98.1	p 109.5

p Preliminary.
[1] Including fuels.
[2] Total includes oil and gas drilling.

Source: Federal Reserve System. Federal Reserve Bulletin. V. 60, No. 3, March 1974, pp. A60–61. Federal Reserve Monthly Statistical Release, Apr. 15, 1974. Federal Reserve System, Industrial Production Indexes, 1972. August 1973, 12 pp.

Table 6.—Net supply of principal minerals by components[1]

(Thousand short tons of mineral content, unless otherwise stated)

Commodity and mineral content measured	Total net supply		Percent change	Components as percent of total, before subtracting exports						Exports as percent of gross supply	
				Primary shipments		Old scrap		Imports			
	1972 r	1973 p		1972 r	1973	1972 r	1973	1972 r	1973	1972 r	1973
FERROUS METALS											
Iron ore ---------thousand long tons--	111,550	131,203	+17.6	69	68	--	--	31	32	2	2
Pig iron	89,675	101,670	+13.4	99	100	--	--	1	(2)	(2)	(2)
Steel ingot	147,853	145,837	− 1.4	88	91	--	--	12	9	2	3
Chromite (Cr_2O_3)	479	391	−18.4	--	--	--	--	100	100	4	5
Cobalt	12	16	+33.3	52	49	--	--	48	51	8	13
Manganese	768	665	−13.4	(2)	(2)	--	--	100	100	3	8
Molybdenum	28	32	+14.3	99	99	--	--	1	1	45	54
Nickel	200	214	+ 7.0	8	8	14	11	78	81	10	9
Tungsten	6	9	+50.0	55	40	--	--	45	60	1	1
OTHER METALS											
Aluminum	4,845	4,524	− 6.6	81	90	4	4	15	6	6	11
Antimony	47	44	− 6.4	1	1	48	51	51	48	(2)	1
Beryl (BeO) ---------short tons--	W	W	W	W	W	--	--	W	W	--	--
Cadmium ---------do----	5,942	6,097	+ 2.6	81	69	--	--	19	31	8	2
Copper	2,433	2,536	+ 4.2	67	67	19	19	14	14	1	2
Lead	1,492	1,493	(2)	40	39	40	43	20	18	3	3
Magnesium	101	105	+ 4.0	94	95	2	3	4	2	15	27
Mercury ---------76-pound flasks--	47,918	58,184	+21.4	15	4	25	18	60	78	1	1
Platinum group ---------thousand troy ounces--	1,555	1,981	+27.4	(2)	(2)	12	10	88	90	26	24
Tin ---------thousand long tons--	71	63	−11.3	NA	NA	28	30	72	70	1	5
Titanium concentrate (TiO_2):											
Ilmenite and slag	718	703	− 2.1	59	66	--	--	41	34	(2)	(2)
Rutile	221	241	+ 9.0	--	--	--	--	100	100	--	--
Uranium concentrate (U_3O_8)	15	19	+26.7	87	68	--	--	13	32	--	--
Zinc	1,257	1,308	+ 4.1	38	36	6	7	56	57	(2)	1
NONMETALS											
Asbestos	815	877	+ 7.6	15	16	--	--	85	84	6	7
Barite, crude	1,530	1,820	+19.0	59	61	--	--	41	39	--	--
Bromine	193	209	+ 8.3	100	100	--	--	--	--	--	--
Clays	57,677	62,312	+ 8.0	100	100	--	--	(2)	(2)	3	3
Fluorspar, finished	1,429	1,458	+ 2.0	17	17	--	--	83	83	(2)	(2)
Gypsum	32,050	33,748	+ 5.3	76	77	--	--	24	23	(2)	(2)
Mica (except scrap)	119	133	+11.8	96	96	--	--	4	4	5	6
Phosphate rock (P_2O_5)	8,221	8,670	+ 5.5	100	100	--	--	(2)	(2)	36	34
Potash (K_2O equivalent)	4,815	5,570	+15.7	47	44	--	--	53	56	14	14
Salt, common	47,616	46,488	− 2.4	93	93	--	--	7	7	2	1
Sand and gravel ---------million tons--	914	984	+ 7.7	100	100	--	--	(2)	(2)	(2)	(2)
Stone, crushed ---------do----	919	1,059	+15.2	100	100	--	--	(2)	(2)	(2)	(2)
Sulfur, all forms ---------thousand long tons--	9,554	10,366	+ 8.5	90	90	--	--	10	10	16	15
Talc and allied minerals	965	1,090	+13.0	97	98	--	--	3	2	15	14

p Preliminary. r Revised. NA Not available. W Withheld to avoid disclosing company confidential data. Figure is not included in net and gross supply.

[1] Net supply is sum of primary shipments, secondary production, and imports minus exports. Stockpile disposals are included in primary shipments. Gross supply is the total before subtraction of exports.

[2] Less than ½ unit.

Table 7.—Shipments, net new orders, and yearend unfilled orders for selected mineral processing industries

(Million dollars)

Year and month	Shipments[1]			Net new orders[1]			Unfilled orders at end of period[1]		
	Primary metals	Blast furnaces	All other primary metals[2]	Primary metals	Blast furnaces	All other primary metals[2]	Primary metals	Blast furnaces	All other primary metals[2]
1969	57,137	26,493	30,644	58,491	27,821	31,210	7,657	3,896	3,761
1970 r	53,242	25,032	28,210	52,413	24,910	27,503	6,599	3,734	2,865
1971 r	55,083	26,656	28,427	54,537	26,362	28,175	6,043	3,432	2,611
1972 r	57,941	28,109	29,832	60,143	29,813	30,330	7,964	5,008	2,686
1973	72,027	35,260	36,767	78,642	39,913	38,729	14,844	9,884	4,960
1973:									
January	5,449	2,751	2,698	5,694	2,819	2,875	8,209	5,076	3,133
February	5,652	2,820	2,832	6,015	3,061	2,954	8,572	5,317	3,255
March	5,634	2,784	2,850	6,500	3,459	3,041	9,438	5,992	3,446
April	5,471	2,595	2,876	6,656	3,604	3,052	10,623	7,000	3,623
May	5,710	2,704	3,006	7,042	3,729	3,313	11,954	8,025	3,929
June	5,789	2,753	3,036	7,015	3,817	3,198	13,181	9,089	4,092
July	6,023	2,924	3,099	6,658	3,493	3,165	13,815	9,658	4,157
August	6,165	3,030	3,135	7,150	3,912	3,238	14,798	10,540	4,258
September	6,226	3,149	3,077	6,325	3,068	3,257	14,857	10,459	4,398
October	6,730	3,459	3,271	6,868	3,309	3,559	14,996	10,309	4,687
November	6,792	3,367	3,425	6,730	3,109	3,621	14,934	10,051	4,883
December	6,687	3,181	3,530	6,597	3,000	3,597	14,844	9,894	4,950

r Revised.
[1] Monthly figures are seasonally adjusted and may not add to totals.
[2] "All other primary metals" obtained by subtracting blast furnace from primary metals figures.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 51–54, No. 2, February 1971–74, pp. S-5, S-6, S-7; v. 54, No. 6, June 1974, p. S-6.

Table 8.—Index of stocks of crude minerals at mines or in hands of primary producers at yearend

(1967=100)

Yearend	Metals and nonmetals[1]	Metals: Total	Iron ore	Other ferrous	Nonferrous	Nonmetals[1]
1969	118	104	106	83	107	136
1970	131	113	118	93	99	154
1971	148	147	136	275	101	149
1972	141	143	113	428	78	138
1973 p	110	95	84	208	67	129

p Preliminary.
[1] Excludes fuels.

Table 9.—Index of stocks of mineral manufacturers, consumers, and dealers at yearend

(1967=100)

Yearend	Metals and nonmetals[1]	Metals: Total	Iron	Other ferrous	Base nonferrous	Other nonferrous	Nonmetals[1]
1969	93	93	85	103	110	74	91
1970	106	106	93	113	126	93	101
1971	103	104	99	135	109	96	88
1972	95	95	88	135	101	87	94
1973 p	85	85	79	99	92	79	91

p Preliminary.
[1] Excludes fuels.

Table 10.—Physical stocks of mineral energy resources and related products at yearend

(Producers' stocks, unless otherwise indicated)

Fuels	1969	1970	1971	1972	1973 p
Coal and related products:					
Bituminous coal and lignite [1] short tons	80,482,000	92,275,000	89,985,000	115,372,000	99,022,000
Coke do	3,120,000	4,113,000	3,510,000	2,941,000	1,184,000
Petroleum and related products:					
Carbon black thousand pounds	208,020	296,087	296,028	237,695	320,325
Natural gasoline, plant condensates, and isopentane thousand barrels	5,704	7,046	6,176	6,075	7,835
Crude petroleum and petroleum products [2] do	974,419	1,010,815	1,037,771	952,904	1,000,472
Crude petroleum do	265,227	276,367	259,648	246,395	242,478
Gasoline do	217,392	214,348	223,771	217,149	209,395
Special naphthas do	6,292	6,193	5,384	5,232	4,514
Liquefied gases [3] do	59,602	67,043	94,713	85,717	83,086
Distillate fuel oil do	171,714	195,271	190,622	154,319	196,421
Residual fuel oil do	58,395	53,994	59,681	55,216	53,480
Petroleum asphalt do	16,753	15,779	21,202	21,636	15,024
Other products do	179,044	181,820	182,750	167,240	196,074
Natural gas [4] billion cubic feet	2,852	3,207	3,523	3,523	3,906

p Preliminary.
[1] Stocks at industrial, consumer, and retail yards and on upper lake docks.
[2] Includes natural gas liquids.
[3] Includes ethane.
[4] American Gas Association.

Table 11.—Seasonally adjusted book value of product inventories for selected mineral processing industries

(Million dollars)

End of year or month	Petroleum and coal products	Stone, clay, and glass products	Primary metals: Blast furnace and steel mills	Primary metals: Other primary metals [1]	Primary metals: Total
1969: December r	2,150	2,126	4,419	3,862	8,281
1970: December r	2,418	2,278	4,854	4,285	9,139
1971: December r	2,367	2,362	4,913	4,306	9,219
1972: December r	2,300	2,463	5,268	4,390	9,658
1973:					
December	2,653	2,791	4,645	4,669	9,314
January	2,262	2,468	5,161	4,414	9,575
February	2,280	2,446	5,043	4,440	9,483
March	2,268	2,495	4,915	4,450	9,365
April	2,345	2,477	4,925	4,500	9,425
May	2,321	2,524	4,940	4,485	9,425
June	2,335	2,593	4,830	4,561	9,391
July	2,412	2,669	4,869	4,583	9,452
August	2,388	2,679	4,820	4,526	9,346
September	2,391	2,702	4,791	4,532	9,323
October	2,474	2,720	4,677	4,545	9,222
November	2,548	2,737	4,617	4,609	9,226

r Revised.
[1] "Other primary metals" obtained by subtracting blast furnace from primary metal figures.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 51, October 1971 p. S-6; v. 54, January and February 1974, p. S-6.

Table 12.—Value of selected minerals and mineral products imported and exported by the United States in 1973, by commodity group and commodity [1]

(Thousand dollars)

SITC code [2]		Exports	Imports
	Minerals, nonmetallic (crude):		
271	Fertilizers, crude	114,340	7,301
273	Stone, sand, and gravel	23,194	29,733
274	Sulfur and unroasted iron pyrites	34,488	14,855
275	Natural abrasives (including industrial diamonds)	48,693	79,856
276	Other crude minerals	167,621	221,221
	Total [3]	388,335	352,966
	Metals (crude and scrap):		
281	Iron ore and concentrates	37,921	533,836
282	Iron and steel scrap	598,498	21,542
283	Ores and concentrates of nonferrous base metals	183,949	465,699
284	Nonferrous metal scrap	242,727	84,358
285	Platinum and platinum-group metal ores and concentrates	16,975	82,653
286	Uranium and thorium ores and concentrates	750	254
	Total	1,080,820	1,188,342
	Mineral energy resources and related products:		
321	Coal, coke, and briquets (including peat)	1,051,985	59,754
331	Petroleum, crude and partly refined	2,621	4,584,326
332	Petroleum products, except chemicals	515,403	2,954,298
341	Gas, natural and manufactured	100,497	492,832
	Total	1,670,506	8,091,210
	Chemicals:		
	Inorganic chemicals:		
513	Elements, oxides, and halogen salts	337,888	429,024
514	Other inorganic chemicals	205,990	95,745
515	Radioactive and associated materials except uranium and thorium	283,560	150,747
521	Mineral tar, crude chemicals from coal, petroleum, and natural gas	72,469	6,025
	Total	899,907	681,541
	Minerals, nonmetallic (manufactured):		
661	Lime, cement, and fabricated building material, except glass and clay	23,129	150,803
662	Clay and refractory construction materials	78,585	78,436
663	Mineral manufactures, not elsewhere specified	114,130	68,616
	Total	215,844	297,855
	Metals (manufactured):		
671	Pig iron, spiegeleisen, sponge iron, iron and steel powder and shot, and ferroalloys	42,545	240,199
672	Iron or steel ingots and other primary forms	74,168	30,886
673	Iron or steel bars, rods, angles, shapes, and sections	174,167	761,251
674	Iron or steel universals, plates, or sheets	381,880	1,326,935
675	Iron or steel hoops and strips	83,076	64,309
676	Iron or steel rails and railway track construction materials	24,895	7,603
677	Iron or steel wire (excluding wire rod)	20,615	164,845
678	Iron or steel tubes, pipes, and fittings	344,738	395,632
679	Iron or steel castings or forgings, unworked	154,713	16,896
681	Silver, platinum, and platinum-group metals	106,475	455,029
682	Copper and copper alloys	383,468	655,131
683	Nickel and nickel alloys	61,573	374,270
684	Aluminum and aluminum alloys	345,513	286,442
685	Lead and lead alloys	27,097	53,252
686	Zinc and zinc alloys	20,924	274,740
687	Tin and tin alloys	13,379	198,758
688	Uranium and thorium metals and alloys	270	3
689	Miscellaneous nonferrous base metals	98,355	128,901
	Total	2,357,851	5,435,082
	Grand total	6,613,263	16,046,996

[1] Data in this table are for the indicated SITC numbers only, and therefore may not correspond to the figures classified by commodity in the "Statistical Summary" chapter of this volume.
[2] Standard Industrial Trade Classification.
[3] Data may not add to totals shown because of independent rounding.

Source: U.S. Department of Commerce, Bureau of the Census. U.S. Imports General and Consumption. FT 135, December 1973, table 1. U.S. Exports Commodity and Country. FT 410, December 1973, table 1.

Table 13.—Percentage distribution of exports of selected minerals and mineral fuels and related products in 1973, by area of destination

SITC code [1]	Commodity	North America [2]	South America	Europe	Asia	Africa	Oceania	Soviet bloc [3]	Undesignated area [4]
271	Fertilizers, crude	35	6	27	30	--	--	2	(5)
273	Stone, sand and gravel	78	3	9	6	1	1	--	2
274	Sulfur and unroasted iron pyrites	42	6	24	26	(5)	(5)	2	(5)
275	Natural abrasives, including industrial diamonds	9	10	64	8	1	6	1	1
276	Crude minerals, not elsewhere specified	29	5	38	23	1	3	(5)	1
281	Iron ore and concentrates	87	--	(5)	13	--	--	--	(5)
282	Iron and steel scrap	19	3	17	61	(5)	(5)	--	(5)
283	Ores and concentrates of nonferrous base metal	7	3	56	34	(5)	(5)	(5)	(5)
284	Nonferrous metal scrap	13	3	40	43	1	(5)	(5)	(5)
286	Uranium and thorium ores and concentrates	100	--	--	--	--	--	--	--
321	Coke, coal, and briquets, including peat	65	7	25	2	(5)	--	1	(5)
331	Petroleum, crude and partly refined	--	--	41	49	--	--	--	(5)
332	Petroleum products, except chemicals	27	7	29	34	1	1	1	(5)
341	Gas, natural and manufactured	64	--	(5)	36	(5)	(5)	--	(5)
513	Inorganic chemical elements, oxides, and halogen salts	35	13	27	14	4	4	2	1
514	Other inorganic chemicals	33	12	23	22	4	4	1	1
515	Radioactive and associated materials	14	(5)	44	42	(5)	(5)	--	(5)
521	Mineral tar and crude chemicals from coal, petroleum, and natural gas	14	11	56	16	3	(5)	(5)	(5)
661	Lime, cement, and fabricated building materials except glass and clay	50	2	34	8	1	1	(5)	4
662	Clay and refractory construction materials	52	9	22	9	2	3	1	2
663	Mineral manufactures, not elsewhere specified	43	5	30	14	2	3	(5)	3
671	Pig iron, sponge iron, iron or steel powders or shot, and ferroalloys	34	4	43	13	1	1	3	1
672	Iron and steel ingots and other primary forms	23	42	18	16	1	(5)	--	(5)
673	Iron and steel bars, rods, angles, shapes, and sections	59	16	6	15	2	1	(5)	1
674	Iron and steel plates and sheets	32	26	16	20	3	--	3	(5)
675	Iron and steel hoop and strip	37	10	43	3	2	4	(5)	1
676	Iron and steel rails and railway track construction materials	28	58	6	5	1	1	(5)	1
677	Iron and steel wire (except insulated electric)	49	6	27	12	1	2	--	3
678	Iron and steel tubes, pipes, and fittings	38	11	14	23	8	2	3	1
679	Iron and steel castings and forgings (rough)	86	2	6	4	19	1	1	(5)
681	Silver, platinum, and platinum-group metals	18	2	29	50	(5)	1	--	(5)
682	Copper and copper alloys	17	11	44	28	(5)	(5)	(5)	(5)
683	Nickel and nickel alloys	36	6	44	11	(5)	2	--	1
684	Aluminum and aluminum alloys	49	8	27	13	2	1	(5)	(5)
685	Lead and lead alloys	9	11	37	42	(5)	(5)	--	1
686	Zinc and zinc alloys	22	27	20	29	1	(5)	--	1
687	Tin and tin alloys	33	59	47	13	(5)	--	1	1
688	Uranium and thorium and their alloys	10	--	61	27	--	--	--	2
689	Base metals and alloys not elsewhere specified	21	6	52	18	1	1	(5)	1

[1] Standard Industrial Trade Classification.
[2] Includes Trinidad and Netherlands Antilles.
[3] U.S.S.R., Bulgaria, East Germany, Albania, Czechoslovakia, Hungary, Poland, Romania, People's Republic of China, North Korea, North Vietnam, and Yugoslavia.
[4] Special category exports.
[5] Less than ½ unit.

Source: U.S. Department of Commerce, Bureau of the Census. U.S. Export Schedule B, Commodity and Country. FT 410, December 1973, table 2.

SITC code [1]	Commodity	North America	South America	Europe	Asia	Africa	Oceania	Soviet bloc [2]	Unidentified
2713000	Phosphates, crude and apatite	78	--	11	--	11	--	--	--
2732100	Gypsum	99	--	1	(3)	--	--	--	--
2743000	Sulfur	99	--	1	--	(3)	--	--	--
2752400	Natural abrasives	2	--	91	5	2	--	--	--
2762200	Graphite, natural	33	(3)	27	25	15	(3)	--	--
2762500	Magnesia, refractory and caustic-calcined, and crude magnesite	1	--	77	21	--	1	--	--
2763000	Salt	94	5	1	(3)	--	--	--	--
2764000	Asbestos	94	--	(3)	--	6	--	--	--
2765200	Mica, including scrap	1	36	--	54	9	--	--	--
2765420	Fluorspar	64	2	30	--	4	--	--	--
2769300	Barite, crude	27	18	44	3	8	--	--	--
2769500	Talc	12	--	54	34	--	--	--	--
2810000	Iron ore and concentrates	58	36	1	(3)	5	--	--	--
2820000	Iron and steel scrap	94	1	5	(3)	(3)	(3)	--	--
2831100	Copper ores and concentrates	48	35	(3)	16	1	--	--	--
2833000	Bauxite	64	32	(3)	--	1	3	--	--
2834000	Lead ores and concentrates	37	36	(3)	--	--	27	--	--
2835000	Zinc ores and concentrates	89	8	2	--	--	1	--	--
2836000	Tin ores and concentrates	--	99	(3)	--	1	--	--	--
2837000	Manganese ores and concentrates	7	42	--	--	44	7	--	--
2839100	Chrome ores	(3)	(3)	(3)	31	40	--	29	--
2839200	Tungsten ores and concentrates	36	34	5	18	4	3	--	--
2839310	Tantalum, molybdenum, and vanadium ores and concentrates	43	17	3	--	11	26	--	--
2839320, 3218000	Titanium ores and concentrates	22	--	1	8	--	69	--	--
2839340	Zirconium ore	1	(3)	3	(3)	--	89	7	--
2839910	Antimony ores and needles	8	37	1	9	45	--	--	--
2839920	Beryllium ores and concentrates	--	62	1	--	29	8	--	--
2839930	Columbium ores and concentrates	(3)	77	4	6	13	--	--	--
2840200	Copper waste and scrap	92	(3)	8	(3)	--	--	--	--
2840300	Nickel waste and scrap	48	(3)	42	1	8	1	--	--
2840400	Aluminum waste and scrap	86	4	9	(3)	1	--	--	--
2840500	Magnesium waste and scrap	15	--	70	6	8	1	--	--
2840600	Lead waste and scrap	87	--	13	--	--	--	--	--
2840700	Zinc waste and scrap	98	--	2	--	--	--	--	--
2840900	Tin waste and scrap	38	50	9	3	--	--	--	--
2850140, 2850240	Platinum-group metals, ores, concentrates, and waste	11	5	59	(3)	24	1	--	--
2860000	Thorium ores and concentrates	--	--	--	100	--	--	--	--
3214000, 3218000, 3219000	Coal, coke, and briquets	26	--	73	--	--	(3)	1	--
3310000	Petroleum, crude and partly refined	29	22	(3)	10	18	(3)	(3)	21
3320000	Petroleum products, except chemicals	45	29	14	8	2	(3)	2	--
3410000	Gases, natural and manufactured	85	11	2	1	1	(3)	--	--
5132500	Mercury including waste and scrap	45	1	18	2	26	--	8	--
5136500	Alumina	37	10	1	2	1	49	(3)	--
5210000	Mineral tar and crude chemicals from coal, petroleum, and natural gas	15	--	85	(3)	--	--	--	--
5613000	Potassic fertilizers and fertilizer materials	96	(3)	3	1	(3)	--	--	--

[1] Standard Industrial Trade Classification.
[2] U.S.S.R., Bulgaria, East Germany, Albania, Czechoslovakia, Hungary, Poland, Romania, People's Republic of China, North Korea, North Vietnam, and Yugoslavia.
[3] Less than ½ unit.

Source: U.S. Department of Commerce, Bureau of the Census. U.S. Imports. FT 135, December 1973, table 2.

Table 15.—Consumption of major mineral products, mineral fuels, and electricity 1972, 1973, and projections

Commodity	1972	1973 p	2000
MINERAL PRODUCTS			
Ferrous metals:			
Iron ore (including agglomerates) --thousand long tons--	126,943	146,922	NA
Raw steel (production) ----thousand short tons--	133,241	150,799	NA
Chromite ores (gross weight):			
Metallurgical grade ----do----	727	920	NA
Refractory grade ----do----	224	261	NA
Chemical grade ----do----	189	206	NA
Manganese ore (35% or more Mn) ----do----	2,331	2,140	3,900
Molybdenum (Mo content) ----thousand pounds--	45,558	57,049	188,000
Tungsten (W content) ----do----	14,107	15,386	76,400
Nonferrous metals:			
Aluminum (apparent consumption) -thousand short tons--	5,588	5,685	28,400
Antimony, primary ----short tons--	16,124	20,613	48,000
Copper, refined ----thousand short tons--	2,239	2,402	7,100
Lead, primary and secondary ----do----	1,485	1,541	2,730
Zinc, all classes ----do----	1,844	1,932	3,090
Mercury, primary ----76-pound flasks--	52,907	54,283	102,000
Platinum-group metals ----thousand troy ounces--	1,562	1,831	3,157
Silver (industrial consumption) ----do----	151,063	195,941	420,000
Ilmenite and titanium slag (estimated TiO_2 content) short tons--	649,030	678,518	1,840,000
Uranium (U_3O_8, estimated purchases by private industry) do----	11,600	12,100	73,113
Nonmetals:			
Asbestos (apparent consumption) --thousand short tons--	809	876	2,430
Cement (apparent consumption) ----do----	85	90	NA
Clays (apparent consumption) ----do----	59,456	61,520	174,000
Lime (sold or used) ----do----	20,290	21,090	NA
Phosphate rock (P_2O_5 content, apparent consumption) do----	13,753	13,972	NA
Potash (K_2O content, apparent consumption) ----do----	4,815	5,570	14,455
Salt (apparent consumption) ----do----	47,616	46,488	158,900
Sand and gravel ----million short tons--	914	984	3,200
Stone, crushed (sold or used) ----do----	920	1,060	3,400
Sulfur, all forms (apparent consumption) thousand long tons--	9,584	10,234	30,000
MINERAL ENERGY RESOURCES AND ELECTRICITY			
Bituminous coal ----million short tons--	517	556	1,000
Coal carbonized for coke [1] ----do----	(87)	(94)	(115)
Anthracite ----do----	6	6	2
Petroleum production and natural gas liquids million barrels--	5,990	6,298	14,500
Natural gas, dry [2] ----million cubic feet--	22,429	22,245	49,000
Electricity generation, net ----million kilowatt-hours--	1,853,390	1,948,070	NA
Utilities ----do----	1,747,323	1,849,260	[3] 9,010,000
Hydropower [4] ----do----	280,478	279,053	[3] 700,000
Nuclear power ----do----	54,031	83,292	[3] 5,470,000
Conventional fuel-burning plants ----do----	1,420,558	1,494,914	[3] 2,840,000
Industrial ----do----	106,067	98,810	NA
Total energy resources inputs ----trillion Btu--	71,946	74,742	[3] 191,900

p Preliminary. NA Not available.
[1] Figures in parentheses are not added to totals.
[2] Residual gas excludes extraction loss but includes transmission loss.
[3] Dupree, W. G., Jr., and J. A. West. U.S. Energy Through Year 2000. U.S. Department of the Interior, December 1972, tables 1 and 8.
[4] Net generations adjusted for net imports or exports. The bulk of net trade is hydropower with an undetermined amount of steam plant power.

Table 16.—Production of mineral energy resources and electricity from hydropower and nuclear power

(Trillion Btu)

Year	Anthracite	Bituminous coal and lignite [1]	Natural gas, wet (unprocessed)	Crude petroleum [2]	Electricity [3]		Total
					Hydropower	Nuclear power	
1969	266	13,957	22,838	18,886	2,648	146	58,741
1970	247	14,820	24,154	19,772	2,630	229	61,852
1971	222	13,385	24,805	19,322	2,825	404	60,963
1972	181	14,319	24,792	19,344	2,866	576	62,078
1973 p	174	14,214	24,876	18,818	2,847	888	61,817

p Preliminary.
[1] Heat values employed for bituminous coal and lignite are 1969, 12,450 Btu per pound; 1970, 12,290 Btu; 1971, 12,120 Btu; 1972, 12,025 Btu; and 1973, 12,025 Btu.
[2] Heat values employed for crude petroleum are 1969, 5,601,070 Btu per barrel; 1970, 5,620,900 Btu; 1971, 5,594,100; 1972, 5,598,100; and 1973, 5,598,900 Btu.
[3] Hydropower and nuclear power include installations owned by manufacturing plants and mines as well as government and privately owned public utilities. The fuel equivalent of hydropower and nuclear power is calculated from the kilowatt-hours produced, converted to theoretical energy resources inputs calculated from national average heat rates for fossil-fueled steam electric plants provided by the Federal Power Commission using 10,398 Btu per net kilowatt-hour in 1968, 10,447 Btu in 1969, and 10,494 Btu in 1970. The heat rate used for hydropower in 1971 is 10,478 Btu per net kilowatt-hour generated and 10,379 Btu in 1972 and 1973. Energy inputs for nuclear power from 1971 through 1973 are converted at an average heat rate of 10,660 Btu per net kilowatt-hour based on information from the Atomic Energy Commission.

Table 17.—Calculated gross consumption of mineral energy resources, and electricity from hydropower and nuclear power in British thermal units (Btu) and percent contributed by each [1]

Year	Anthracite	Bituminous coal and lignite	Natural gas, dry	Petroleum (excluding natural gas liquids)	Natural gas liquids	Electricity		Total
						Hydropower	Nuclear power	
TRILLION BTU								
1969	224	12,509	21,020	26,029	2,392	2,659	146	64,979
1970	210	12,488	22,029	27,049	2,488	2,650	229	67,143
1971	186	11,857	22,819	28,045	2,525	2,862	404	68,698
1972	150	12,273	23,035	30,382	2,584	2,946	576	71,946
1973 p	144	13,206	22,846	32,170	2,558	2,930	888	74,742
PERCENT								
1969	.3	19.3	32.3	40.1	3.7	4.1	.2	100.0
1970	.3	18.6	32.8	40.3	3.7	4.0	.3	100.0
1971	.3	17.3	33.2	40.8	3.7	4.1	.6	100.0
1972	.2	17.1	32.0	42.2	3.6	4.1	.8	100.0
1973 p	.2	17.7	30.6	43.0	3.4	3.9	1.2	100.0

p Preliminary.
[1] Heat values employed are anthracite, 12,700 Btu per pound, and bituminous coal and lignite, weighted average British thermal units provided by the Division of Fossil Fuels, Branch of Coal, 12,330 Btu per pound in 1969; 12,110 Btu per pound in 1970; 11,980 Btu per pound in 1971; 11,875 Btu per pound in 1972 and 1973. Weighted average Btu for petroleum products obtained by using 5,248,000 Btu per barrel for gasoline and naphtha-type jet fuel, 5,670,000 for kerosine and kerosine-type jet fuel, 5,825,000 for distillate, 6,287,000 for residual, 6,064,800 for lubricants, 5,537,280 for wax, 6,636,000 for asphalt, and 5,796,000 for miscellaneous. Natural gas dry, 1,031 Btu per cubic foot in 1969–71; 1,027 Btu in 1972–73; natural gas liquids, weighted average British thermal units: natural gasoline and cycle products, 110,000 Btu per gallon; LP-gases, 95,500 Btu per gallon; and ethane, 73,390 Btu per gallon. Hydropower (adjusted for net imports or net exports) and nuclear power are derived from net electricity generated, converted to theoretical energy resources inputs calculated from national average heat rates for fossil-fueled steam-electric plants provided by the Federal Power Commission, using 10,447 Btu per net kilowatt-hour in 1969, and 10,494 Btu in 1970. The heat rate used for hydropower in 1971 is 10,478 Btu per net kilowatt-hour generated, and 10,379 Btu in 1972 and 1973. Energy inputs for nuclear power 1971–73 are converted at an average heat rate of 10,660 Btu per net kilowatt-hour based on information from the Atomic Energy Commission.

Table 18.—Gross consumption of energy resources, by major sources and consuming sector [1]

(Trillion Btu)

Year	Anthracite	Bituminous coal and lignite	Natural gas dry [1]	Petroleum [2]	Hydro-power [3]	Nuclear power [3]	Total gross energy inputs [4]	Utility electricity distributed [5]	Total energy inputs [6]
HOUSEHOLD AND COMMERCIAL									
1969	107	340	6,890	6,268	XX	--	13,605	2,752	16,357
1970	103	324	7,108	6,453	--	--	13,988	3,000	16,988
1971	98	308	7,366	6,440	--	--	14,212	3,209	17,421
1972	75	233	7,613	6,667	--	--	14,588	3,478	18,066
1973 p	74	221	7,361	7,060	--	--	14,716	3,696	18,412
INDUSTRIAL									
1969	70	4,981	9,885	5,047	34	--	20,017	2,155	22,172
1970	59	4,943	10,161	5,061	34	--	20,258	2,210	22,468
1971	47	4,256	10,570	5,094	34	--	20,001	2,293	22,294
1972	35	4,240	10,549	5,668	35	--	20,527	2,493	23,020
1973 p	33	4,330	11,034	5,986	34	--	21,417	2,625	24,042
TRANSPORTATION [7]									
1969	NA	8	651	15,249	XX	--	15,908	17	15,925
1970	NA	8	745	15,720	--	--	16,473	16	16,489
1971	NA	6	766	16,286	--	--	17,058	17	17,075
1972	NA	4	787	17,264	--	--	18,055	17	18,072
1973 p	NA	3	748	17,989	--	--	18,740	16	18,756
ELECTRICITY GENERATION, UTILITIES [3]									
1969	47	7,180	3,594	1,628	2,625	146	15,220	4,924	XX
1970	48	7,213	4,015	2,087	2,616	229	16,208	5,226	--
1971	42	7,288	4,117	2,543	2,828	404	17,222	5,519	--
1972	40	7,796	4,086	3,134	2,911	576	18,543	5,988	--
1973 p	37	8,652	3,703	3,465	2,896	888	19,641	6,337	--
MISCELLANEOUS AND UNACCOUNTED FOR									
1969	--	--	--	229	--	--	229	--	229
1970	--	--	--	216	--	--	216	--	216
1971	--	--	--	207	--	--	207	--	207
1972	--	--	--	233	--	--	233	--	233
1973 p	--	--	--	229	--	--	229	--	229
TOTAL ENERGY INPUTS [8]									
1969	224	12,509	21,020	28,421	2,659	146	64,979	XX	54,683
1970	210	12,488	22,029	29,537	2,650	229	67,143	--	56,161
1971	186	11,857	22,819	30,570	2,862	404	68,698	--	56,997
1972	150	12,273	23,035	32,966	2,946	576	71,946	--	59,391
1973 p	144	13,206	22,846	34,728	2,930	888	74,742	--	61,439

[p] Preliminary. NA Not available. XX Not applicable.

[1] Excludes natural gas liquids.

[2] Petroleum products including still gas, LRG, and natural gas liquids.

[3] Represents outputs of hydropower (adjusted for net imports or net exports) and nuclear power converted to theoretical energy inputs calculated from national average heat rates for fossil-fueled steam-electric plants provided by the Federal Power Commission using 10,447 Btu per net kilowatt-hour in 1969 and 10,494 Btu in 1970. Energy inputs for hydropower in 1971 are converted at an average heat rate of 10,478 Btu per net kilowatt-hour generated, and in 1972–73 at 10,379 Btu. Energy inputs for nuclear power in 1971–73 are converted at an average heat rate 10,660 Btu per net kilowatt-hour based on information from the Atomic Energy Commission. Excludes inputs for power generated by nonutility fuel-burning plants which are included within the other consuming sectors.

[4] Gross energy is that contained in all types of commercial energy at the time it is incorporated in the economy, whether energy is produced domestically or imported. Gross energy comprises inputs of primary fuels (or for derivatives) and outputs of hydropower and nuclear power energy converted to theoretical inputs. Gross energy includes energy used for production, processing, and transportation of energy proper.

[5] Utility electricity, generated and imported, distributed to the other consuming sectors as energy resource inputs. Distribution to sectors is based on sales reported in the annual issues of the Edison Electric Institute Yearbook. Conversion of electricity to energy equivalent by sectors was made at the value of contained energy corresponding to 100% efficiency using a theoretical rate of 3,412 Btu per kilowatt-hour.

[6] Energy resource inputs by sector, including direct fuels and electricity distributed.

[7] Includes bunkers and military transportation.

[8] Data may not add to totals shown because of independent rounding.

Table 19.—Domestic supply and demand for coal

	1972		1973 p	
	Thousand short tons	Trillion Btu	Thousand short tons	Trillion Btu
ANTHRACITE				
Supply:				
Production [1]	7,106	180.5	6,830	173.5
Exports [2]	−1,191	−30.3	−1,159	−29.5
Imports	--	--	--	--
Stock change: Withdrawals(+), additions(−)	NA	NA	NA	NA
Losses, gains, unaccounted for	--	--	--	--
Total	5,915	150.2	5,671	144.0
Demand by major consuming sectors: [3]				
Household and commercial [4]	2,960	75.2	2,917	74.1
Industrial [5]	1,371	34.8	1,312	33.3
Electricity generation, utilities	1,584	40.2	1,442	36.6
Total	5,915	150.2	5,671	144.0
BITUMINOUS COAL AND LIGNITE				
Supply:				
Production [1]	595,386	14,319.0	591,000	14,213.6
Exports	−55,960	−1,514.3	−52,870	−1,430.7
Imports	47	1.1	127	3.0
Stock change: Withdrawals(+), additions(−)	−25,121	−604.2	16,437	388.2
Losses, gains, unaccounted for	2,424	71.8	1,328	31.4
Total	516,776	12,273.4	556,022	13,205.5
Demand by major consuming sectors:				
Fuel and power:				
Household and commercial [4]	8,748	232.9	8,200	220.7
Industrial [5]	154,658	4,117.5	156,448	4,211.5
Coal carbonized for coke [6]	(87,272)	(2,323.4)	(93,634)	(2,520.6)
Transportation [7]	163	4.3	116	3.1
Electricity generation, utilities	348,612	7,796.4	386,879	8,652.2
Total [6]	512,181	12,151.1	551,643	13,087.5
Raw material: Industrial: [8]				
Crude light oil	1,071	28.5	1,131	30.5
Crude coal tar	3,524	93.8	3,248	87.5
Total	4,595	122.3	4,379	118.0
Grand total	516,776	12,273.4	556,022	13,205.5

p Preliminary. NA Not available.
[1] Includes use by producers for power and heat.
[2] Includes shipments to U.S. Armed Forces in West Germany.
[3] Except for small quantities used as raw material for coal chemicals, all anthracite is used for fuel and power.
[4] Data represent "retail deliveries to other consumers." These are mainly household and commercial users, with some unknown portion of use by small industries.
[5] Includes consumption by coke plants, steel and rolling mills, and other industrial uses.
[6] Figures in parentheses are not added into totals.
[7] Includes bunkers and military transportation.
[8] Coal equivalent based on British thermal unit value of raw material consumption of coal chemicals listed.

Table 20.—Domestic supply and demand for natural gas

	1972		1973 p	
	Million cubic feet	Trillion Btu	Million cubic feet	Trillion Btu
Supply:				
Production [1]	22,531,698	24,791.8	22,647,549	24,876.0
Exports	−78,013	−80.1	−77,169	−79.3
Imports	1,019,496	1,047.0	1,032,901	1,060.8
Stock change: Withdrawals(+), additions(−)	−135,734	−139.4	−441,504	−453.4
Transfers out, extraction loss [2]	−907,993	−2,584.3	−916,551	−2,558.3
Losses, gains, unaccounted for	--	--	--	--
Total	22,429,454	23,035.0	22,245,226	22,845.8
Demand by major consuming sectors:				
Fuel and power:				
Household and commercial	7,412,543	7,612.7	7,167,428	7,360.9
Industrial [3]	9,618,143	9,877.8	10,044,606	10,315.8
Transportation	766,156	786.8	728,177	747.8
Electricity generation, utilities	3,978,673	4,086.1	3,605,333	3,702.7
Total	21,775,515	22,363.4	21,545,544	22,127.2
Raw material: Industrial: [4]				
Carbon black	53,939	55.4	49,682	51.0
Other chemicals [5]	600,000	616.2	650,000	667.6
Total	653,939	671.6	699,682	718.6
Grand total	22,429,454	23,035.0	22,245,226	22,845.8

p Preliminary.

1 Marketed production includes wet gas sold or consumed by producers, losses in transmission, producers' additions to storage, and increases in gas pipeline fill: excludes repressuring and quantities vented and flared. British thermal unit value of production is for wet gas prior to extraction of natural gas liquids. Higher Btu values assigned to extraction loss are reflected in value of natural gas liquids production for each year.

2 Extraction loss from cycling plants represents offtake of natural gas for natural gas liquids as reported to the Bureau of Mines. Energy equivalent of extraction loss is based on annual outputs of natural gasoline and associated products at 110,000 Btu per gallon, annual outputs of LPG at 95,500 Btu per gallon, and annual outputs of ethane at 93.390 Btu per gallon. (Prior to 1967, ethane production was included with LPG in converting to Btu values.)

3 Includes transmission losses and unaccounted for of 328,002 million cubic feet in 1972 and 195,863 million cubic feet in 1973.

4 Includes some fuel and power used by raw material industries.

5 Estimated from partial data.

NOTE.—Conversion factor for dry gas is 1,027 Btu per cubic foot.

Table 21.—Domestic supply and demand for petroleum [1]

	1972 Million barrels	1972 Trillion Btu	1973 p Million barrels	1973 p Trillion Btu
Supply:				
Crude oil: [2]				
Production	3,455.4	19,343.6	3,360.9	18,817.5
Exports	—.2	—1.1	—0.7	—3.9
Imports [3]	811.1	4,540.5	1,184.0	6,629.1
Stock change: Withdrawals (+), additions (—)	13.3	74.5	3.9	21.8
Losses, transfers for use as fuel, and unaccounted for	1.3	7.2	—10.8	—60.5
Total	4,280.9	23,964.7	4,537.3	25,404.0
Refinery input:				
Crude oil	4,280.9	23,964.7	4,537.3	25,404.0
Transfers in, natural gas liquids [4]	302.4	1,345.4	297.5	1,325.5
Other hydrocarbons	10.1	55.8	10.7	64.2
Total	4,593.4	25,365.9	4,845.5	26,793.7
Refined products:				
Refinery output	4,593.4	25,365.9	4,845.5	26,793.7
Unfinished oil reruns, net	51.5	323.8	45.8	287.9
Processing gain, net	142.2	785.3	165.5	915.2
Total	4,787.1	26,475.0	5,056.8	27,996.8
Exports	—81.2	—462.9	—83.5	—480.2
Imports	924.2	5,571.4	1,079.5	6,448.8
Stocks change, including natural gas liquids	71.7	403.1	—53.2	—284.9
Transfers in natural gas liquids [4,5]	335.8	1,238.9	336.9	1,232.8
Losses, gains, and unaccounted for	—47.3	—259.8	—39.0	—185.1
Total supply	5,990.3	32,965.7	6,297.5	34,728.2
Demand by major consuming sectors:				
Fuel and power:				
Household and commercial	997.6	5,530.7	1,042.3	5,796.1
Industrial	595.5	3,533.1	640.3	3,802.7
Transportation [6]	3,187.2	17,107.4	3,316.6	17,807.2
Electricity generation, utilities	503.7	3,133.8	556.9	3,464.6
Other, not specified	27.2	149.0	22.0	124.3
Total	5,311.2	29,454.0	5,578.1	30,994.9
Raw material: [7]				
Petrochemical feedstock offtake	370.3	1,580.4	383.1	1,626.4
Other nonfuel use	293.5	1,847.7	317.3	2,002.1
Total	663.8	3,428.1	700.4	3,628.5
Miscellaneous and unaccounted for	15.3	83.6	19.0	104.8
Grand total	5,990.3	32,965.7	6,297.5	34,728.2

p Preliminary.

[1] Supply and demand for crude oil and petroleum products. Petroleum products include products refined and processed from crude oil, including still gas and LRG; also natural gas liquids transferred from natural gas.

[2] Btu value for crude oil for each year shown is based on average Btu value of total output of petroleum products (including refinery fuel and losses) adjusted to exclude natural gas liquids inputs and their implicitly derived values. Value for imports of crude is based on the average value of crude runs to stills.

[3] Includes some Athabasca hydrocarbons.

[4] Btu values for natural gas liquids for each year shown are implicitly derived from weighted averages of production of major natural gas liquids, derived by converting natural gasoline and cycle products at 110,000 Btu per gallon, LPG at 95,500 Btu per gallon, and ethane at 73,390 Btu per gallon.

[5] Includes natural gas liquids other than those channeled into refinery input as follows: Petrochemical feedstocks, direct uses for fuel and power, and other uses.

[6] Includes bunkers and military transportation.

[7] Includes some fuel and power used by raw materials industries.

Table 22.—Petroleum consumption, by major product and major consuming sector[1]

	Household and commercial		Industrial		Transportation[2]		Electricity generation, utilities		Miscellaneous and unaccounted for		Total domestic product demand	
	Million barrels	Trillion Btu	Million barrels	Trillion Btu	Million barrels	Trillion Btu	Million barrels	Trillion Btu	Million barrels	Trillion Btu	Million barrels	Trillion Btu
1972												
Fuel and power:												
Liquefied gases	196.5	788.1	34.0	136.4	35.2	141.2	--	--	7.5	30.1	273.2	1,095.8
Jet fuels:												
Naphtha type	--	--	--	--	88.5	473.9	--	--	--	--	88.5	473.9
Kerosine type	--	--	--	--	285.2	1,617.1	8.8	49.9	--	--	294.0	1,667.0
Total	--	--	--	--	373.7	2,091.0	8.8	49.9	--	--	382.5	2,140.9
Gasoline	--	--	--	--	2,350.7	12,336.5	--	--	--	--	2,350.7	12,336.5
Kerosine	66.2	375.4	19.7	111.6	--	--	--	--	--	--	85.9	487.0
Distillate fuel	547.8	3,190.9	124.0	722.3	323.9	1,886.7	59.6	347.2	10.8	62.9	1,066.1	6,210.0
Residual fuel	187.1	1,176.3	190.6	1,198.3	103.7	652.0	435.3	2,736.7	8.9	56.0	925.6	5,819.3
Still gas	--	--	171.0	1,026.0	--	--	--	--	--	--	171.0	1,026.0
Petroleum coke	--	--	56.2	338.5	--	--	--	--	--	--	56.2	338.5
Total	997.6	5,530.7	595.5	3,533.1	3,187.2	17,107.4	503.7	3,133.8	27.2	149.0	5,311.2	29,454.0
Raw material:[3]												
Special naphthas	--	--	31.9	167.4	--	--	--	--	--	--	31.9	167.4
Lubes[4] and waxes	--	--	32.4	193.7	25.8	156.5	--	--	--	--	58.2	350.2
Petroleum coke[5]	--	--	32.1	193.4	--	--	--	--	--	--	32.1	193.4
Asphalt and road oil	171.3	1,136.7	--	--	--	--	--	--	--	--	171.3	1,136.7
Petrochemical feedstock offtake:												
Liquefied refinery gas[6]	--	--	45.9	165.8	--	--	--	--	--	--	45.9	165.8
Liquefied petroleum gas[6 7]	--	--	200.7	724.8	--	--	--	--	--	--	200.7	724.8
Naphtha (−400 degrees)	--	--	58.1	304.9	--	--	--	--	--	--	58.1	304.9
Still gas	--	--	14.7	88.2	--	--	--	--	--	--	14.7	88.2
Miscellaneous (+400 degrees)	--	--	50.9	296.7	--	--	--	--	--	--	50.9	296.7
Total	171.3	1,136.7	466.7	2,134.9	25.8	156.5	--	--	--	--	663.8	3,428.1
Miscellaneous and unaccounted for	--	--	--	--	--	--	--	--	15.3	83.6	15.3	83.6
Grand total, domestic product demand	1,168.9	6,667.4	1,062.2	5,668.0	3,213.0	17,263.9	503.7	3,133.8	42.5	232.6	5,990.3	32,965.7

See footnotes at end of table.

Table 22.—Petroleum consumption, by major product and major consuming sector[1]—Continued

	Household and commercial		Industrial		Transportation [2]		Electricity generation, utilities		Miscellaneous and unaccounted for		Total domestic product demand	
	Million barrels	Trillion Btu	Million barrels	Trillion Btu	Million barrels	Trillion Btu	Million barrels	Trillion Btu	Million barrels	Trillion Btu	Million barrels	Trillion Btu
1973 p												
Fuel and power:												
Liquefied gases	199.0	798.2	36.0	144.4	37.0	148.4	--	--	4.4	17.6	276.4	1,108.6
Jet fuels:												
Naphtha type	--	--	--	--	79.2	424.1	--	--	--	--	79.2	424.1
Kerosine type	--	--	--	--	294.7	1,670.9	9.5	53.9	--	--	304.2	1,724.8
Total	--	--	--	--	373.9	2,095.0	9.5	53.9	--	--	383.4	2,148.9
Gasoline	--	--	--	--	2,452.0	12,868.1	--	--	--	--	2,452.0	12,868.1
Kerosine	60.4	342.5	18.5	104.9	--	--	--	--	--	--	78.9	447.4
Distillate fuel	577.2	3,362.2	132.8	773.6	339.2	1,975.8	66.7	388.5	8.4	48.9	1,124.3	6,549.0
Residual fuel	205.7	1,293.2	209.8	1,319.0	114.5	719.9	480.7	3,022.2	9.2	57.8	1,019.9	6,412.1
Still gas	--	--	176.8	1,060.8	--	--	--	--	--	--	176.8	1,060.8
Petroleum coke	--	--	66.4	400.0	--	--	--	--	--	--	66.4	400.0
Total	1,042.3	5,796.1	640.3	3,802.7	3,316.6	17,807.2	556.9	3,464.6	22.0	124.3	5,578.1	30,994.9
Raw material: [3]												
Special naphthas	--	--	32.2	169.0	--	--	--	--	--	--	32.2	169.0
Lubes [4] and waxes	--	--	36.0	214.7	30.0	182.0	--	--	--	--	66.0	396.7
Petroleum coke [5]	--	--	28.7	172.9	--	--	--	--	--	--	28.7	172.9
Asphalt and road oil	190.4	1,263.5	--	--	--	--	--	--	--	--	190.4	1,263.5
Petrochemical feedstock offtake:												
Liquefied refinery gas [6]	--	--	47.2	167.4	--	--	--	--	--	--	47.2	167.4
Liquefied petroleum gas [6,7]	--	--	205.0	727.1	--	--	--	--	--	--	205.0	727.1
Naphtha (−400 degrees)	--	--	56.8	298.1	--	--	--	--	--	--	56.8	298.1
Still gas	--	--	12.4	74.4	--	--	--	--	--	--	12.4	74.4
Miscellaneous (+400 degrees)	1,232.7	7,059.6	1,120.3	5,985.7	3,346.6	--	--	--	--	--	61.7	359.4
Total	190.4	1,263.5	480.0	2,183.0	30.0	182.0	--	--	--	--	700.4	3,628.5
Miscellaneous and unaccounted for	--	--	--	--	--	--	--	--	19.0	104.8	19.0	104.8
Grand total, domestic product demand	1,232.7	7,059.6	1,120.3	5,985.7	3,346.6	17,989.2	556.9	3,464.6	41.0	229.1	6,297.5	34,728.2

p Preliminary.
[1] Includes liquefied refinery gas and natural gas liquids.
[2] Includes bunkers and military transportation.
[3] Includes some fuel and power used by raw materials industries.
[4] Lubricants are distributed on basis of data from Bureau of the Census survey.
[5] Includes portions of petroleum coke estimated to be consumed in nonfuel uses.
[6] Includes ethane.
[7] Includes LPG for synthetic rubber.

Table 23.—Electrical energy sales to ultimate consumers

(Million kilowatt hours)

Region	Total consumption	Residential	Industrial and commercial	Total consumption	Residential	Industrial and commercial
	1969			1970		
New England	51,373	18,789	31,040	55,255	20,900	32,804
Middle Atlantic	190,582	54,405	124,633	201,230	59,709	129,328
East North-Central	256,212	73,409	172,953	267,228	79,687	177,306
West North-Central	84,125	32,436	48,909	90,414	35,339	52,109
South Atlantic	199,257	72,253	118,360	218,715	81,493	128,261
East South-Central	129,601	39,331	88,308	136,728	43,788	90,760
West South-Central	141,610	43,068	92,037	154,136	47,997	99,380
Mountain	59,067	15,700	40,638	62,592	16,977	42,654
Pacific	190,979	56,940	124,373	200,260	60,171	129,739
Alaska and Hawaii	4,372	1,591	2,655	4,801	1,734	2,931
Total United States	1,307,178	407,922	843,906	1,391,359	447,795	885,272
	1971			1972		
New England	59,072	22,870	34,645	63,782	24,614	37,509
Middle Atlantic	208,567	62,878	133,086	219,861	65,978	140,639
East North-Central	281,393	84,629	186,011	304,297	89,736	203,268
West North-Central	94,872	37,372	54,395	100,687	39,074	58,316
South Atlantic	234,920	87,559	137,798	252,811	93,563	149,062
East South-Central	142,057	45,905	93,823	153,430	48,404	102,441
West South-Central	164,047	51,497	105,361	181,902	57,952	116,218
Mountain	66,168	18,641	44,427	71,805	20,609	47,719
Pacific	209,980	65,814	133,615	223,309	69,441	142,551
Alaska and Hawaii	5,365	1,915	3,291	5,830	2,052	3,603
Total United States	1,466,441	479,080	926,452	1,577,714	511,423	1,001,326

Source: Edison Electric Institute. Statistical Yearbook of the Electric Utility Industry, 1969–1972.

Table 24.—Total employment in selected mineral industries

(Thousands)

	1969	1970	1971	1972	1973
MINING					
Metals:					
Iron ores	25.6	26.2	24.5	20.1	21.3
Copper ores	33.7	37.0	34.7	38.9	42.3
Total [1]	89.4	94.8	89.0	86.1	90.5
Nonmetal mining and quarrying	115.6	116.0	113.0	112.1	115.8
Fuels:					
Bituminous	129.5	138.8	132.3	143.2	158.0
Other coal	5.7	5.6	5.4	3.7	3.6
Crude petroleum and natural gasfields	145.0	141.7	141.0	137.8	133.5
Oil and gasfield services	133.9	125.2	120.3	124.1	131.0
Total	414.1	411.3	399.0	408.8	426.1
Total mining	r 619.1	622.1	601.0	607.0	632.4
MANUFACTURING					
Minerals:					
Fertilizers, complete and mixing only	39.6	40.5	38.2	35.8	38.5
Cement, hydraulic	34.9	34.1	32.0	33.6	33.8
Blast furnaces, steelworks, and rolling mills	561.1	549.6	506.3	492.2	521.8
Nonferrous smelting and refining	86.2	86.3	83.9	83.6	86.3
Total	721.8	710.5	660.4	645.2	680.4
Fuels:					
Petroleum refining	144.7	153.4	153.1	150.8	147.3
Other petroleum and coal products	38.2	38.5	36.7	38.8	40.8
Total [2]	182.9	191.9	189.8	189.6	188.1
Total manufacturing	904.7	902.4	850.2	834.8	868.5

r Revised.
[1] Includes other metal mining not shown separately.
[2] Standard Industrial Classification 295, paving and roofing materials, included in total.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Employment and Earnings. V. 16–20, No. 9, March issue 1970—1974, table B–2.

Table 25.—Average hours and gross earnings of production and related workers in the mineral and mineral fuels industries

	1969	1970	1971	1972	1973
MINING					
Metal:					
Iron ores:					
Weekly earnings	$153.18	$162.99	$169.70	$185.40	$198.56
Weekly hours	41.4	41.9	40.5	41.2	42.7
Hourly earnings	$3.70	$3.89	$4.19	$4.50	$4.65
Copper ores:					
Weekly earnings	$169.00	$175.67	[1] $178.46	$192.19	$206.52
Weekly hours	46.3	44.7	42.9	41.6	42.3
Hourly earnings	$3.65	$3.93	$4.16	$4.62	$4.88
All metal mining: [2]					
Weekly earnings	$157.32	$165.68	$171.39	$185.51	$200.40
Weekly hours	43.1	42.7	41.6	41.5	42.1
Hourly earnings	$3.65	$3.88	$4.12	$4.47	$4.76
Nonmetallic mining and quarrying:					
Weekly earnings	$149.11	$155.56	$165.23	$176.96	$196.88
Weekly hours	45.6	44.7	44.9	44.8	47.1
Hourly earnings	$3.27	$3.48	$3.68	$3.95	$4.18
Fuels:					
All coal mining:					
Weekly earnings	$166.74	$183.96	$194.00	$215.83	$226.86
Weekly hours	39.7	40.7	[3] 40.6	[3] 41.0	39.9
Hourly earnings	$4.20	$4.52	[3] $4.79	[3] $5.30	[3] $5.69
Bituminous coal:					
Weekly earnings	$169.18	$186.46	$196.02	$217.46	$228.45
Weekly hours	39.9	40.8	[3] 40.6	[3] 41.0	39.8
Hourly earnings	$4.24	$4.57	[3] $4.85	[3] $5.34	$5.74
Crude petroleum and natural gas:					
Weekly earnings	$147.19	$155.88	$159.75	$169.92	$191.82
Weekly hours	41.0	40.7	42.6	42.8	40.9
Hourly earnings	$3.59	$3.83	$3.75	$3.97	$4.69
All fuels: [4]					
Weekly earnings	$156.55	$166.35	$173.59	$191.27	$207.22
Weekly hours	42.2	42.1	41.8	41.8	40.8
Hourly earnings	$3.73	$3.97	$4.22	$4.53	$4.90
All mining: [4]					
Weekly earnings	$152.67	$160.07	$167.89	$180.61	$198.39
Weekly hours	44.6	43.8	43.5	43.4	44.0
Hourly earnings	$3.43	$3.66	$3.87	$4.17	$4.70
MANUFACTURING					
Fertilizers, complete and mixing only:					
Weekly earnings	$116.14	$123.68	$132.71	$143.14	$156.66
Weekly hours	42.7	42.5	42.4	42.6	43.0
Hourly earnings	$2.72	$2.91	$3.13	$3.36	$3.62
Cement, hydraulic:					
Weekly earnings	$155.87	$176.81	$194.37	$215.04	$233.20
Weekly hours	41.9	41.8	41.8	42.0	42.4
Hourly earnings	$3.72	$4.23	$4.65	$5.12	$5.50
Blast furnaces, steel and rolling mills:					
Weekly earnings	$168.51	$168.38	$181.43	$210.12	$230.74
Weekly hours	41.2	39.9	39.7	40.8	41.8
Hourly earnings	$4.09	$4.22	$4.57	$5.15	$5.56
Nonferrous smelting and refining:					
Weekly earnings	$152.64	$157.63	$166.83	$185.59	$203.46
Weekly hours	42.4	41.7	41.5	41.8	42.3
Hourly earnings	$3.60	$3.78	$4.02	$4.44	$4.81
Petroleum refining and related industries:					
Weekly earnings	$170.40	$182.33	$194.19	$208.89	$220.28
Weekly hours	42.6	42.7	42.4	42.2	42.2
Hourly earnings	$4.00	$4.27	$4.58	$4.95	$5.22
Petroleum refining:					
Weekly earnings	$178.08	$189.93	$202.44	$219.45	$231.02
Weekly hours	42.1	42.3	42.0	41.8	41.7
Hourly earnings	$4.23	$4.49	$4.82	$5.25	$5.54
Other petroleum and coal products:					
Weekly earnings	$147.52	$157.52	$166.44	$175.34	$187.91
Weekly hours	44.3	44.0	43.8	43.4	43.7
Hourly earnings	$3.33	$3.58	$3.80	$4.04	$4.30
All manufacturing: [4]					
Weekly earnings	$165.47	$168.76	$181.46	$206.52	$224.92
Weekly hours	41.7	40.5	40.4	41.1	41.7
Hourly earnings	$3.99	$4.16	$4.49	$5.02	$5.41

[1] Corrected figure.
[2] Includes other metal mining not shown.
[3] 11-month average.
[4] Weighted average of data computed using figures for production workers as weights.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Employment and Earnings, United States, 1909–70. Bull. 1312–7, September 1971, 602 pp. U.S. Department of Labor, Bureau of Labor Statistics. Employment and Earnings. V. 17–20, No. 9, March issue 1971, 1972, 1973, 1974, table C–2.

Table 26.—Wages, salaries, and average annual earnings in the United States

	1971 r	1972	1973 p	Percent change 1971–72	Percent change 1972–73
Wages and salaries:					
All industries, total ----------millions--	$573,590	$626,781	$691,620	+9.3	+10.3
Mining ----------do----	6,056	6,708	7,361	+10.8	+9.7
Manufacturing ----------do----	160,635	175,644	196,585	+9.3	+11.9
Average earnings per full-time employee:					
All industries, total ----------	8,059	8,610	9,106	+6.8	+5.8
Mining ----------	9,831	10,665	11,448	+8.5	+7.3
Manufacturing ----------	8,640	9,201	9,758	+6.5	+6.1

p Preliminary. r Revised.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 53, No. 7, July 1974, p. 36, table 6.2; p. 37, table 6.5.

Table 27.—Average labor-turnover rates in selected mineral industries [1]

(Per thousand employees)

Rates and year	Manufacturing	Cement, hydraulic	Blast furnaces, steel and rolling mills	Nonferrous smelting and refining	Metal mining	Iron ores	Copper ores	Petroleum refining and related industries [2]	Petroleum refining	Coal mining
Total accession rate:										
1971 ----------	39	20	35	23	29	23	28	18	13	19
1972 ----------	44	16	31	25	34	29	32	18	13	18
1973 ----------	48	17	25	26	38	27	39	22	16	17
Total separation rate:										
1971 ----------	42	19	46	31	33	31	28	20	16	17
1972 ----------	42	16	22	25	35	33	27	20	16	19
1973 ----------	46	16	21	25	34	21	34	22	15	16
Layoff rate:										
1971 ----------	16	7	30	11	7	14	4	6	5	3
1972 ----------	11	5	8	5	8	18	2	6	5	6
1973 ----------	9	3	4	4	3	5	1	5	5	3

[1] Monthly rates are available in Employment and Earnings as indicated in source.
[2] Standard Industrial Classification 295, paving and roofing materials, included in total.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Employment and Earnings. V. 18–20, No. 9, March issue 1972, 1973, and 1974, table D-2.

Table 28.—Labor productivity indexes for selected minerals

(1967=100)

Year	Copper, crude ore mined per—			Iron, crude ore mined per—		
	Employee	Production worker	Production worker man-hour	Employee	Production worker	Production worker man-hour
1968	121.1	119.8	109.6	108.2	109.2	110.0
1969	133.1	125.2	116.2	113.4	116.2	117.8
1970	140.3	131.9	126.9	r 115.8	r 117.8	r 118.0
1971	140.5	136.9	137.2	115.8	119.0	123.4
1972 p	143.1	136.6	141.1	131.7	136.4	139.1
	Copper, recoverable metal mined per—			Iron, usable ore mined per—		
	Employee	Production worker	Production worker man-hour	Employee	Production worker	Production worker man-hour
1968	114.3	113.1	103.4	103.4	104.4	105.1
1969	122.4	115.1	106.9	105.4	108.0	109.6
1970	124.7	117.2	112.8	r 106.6	r 108.4	r 108.7
1971	117.4	114.3	114.6	103.8	106.7	110.6
1972 p	112.4	107.3	110.9	114.9	119.0	121.5
	Petroleum, refined per—			Bituminous coal and lignite mined per—		
	Employee	Production worker	Production worker man-hour	Employee	Production worker	Production worker man-hour
1968	103.8	104.5	103.7	103.1	103.9	105.1
1969	110.7	113.1	110.6	103.3	103.9	105.4
1970 r	108.4	109.7	108.6	103.1	103.5	103.2
1971	113.1	115.1	115.3	98.1	101.4	101.6
1972 p	119.7	121.0	121.8	98.4	100.8	100.1

p Preliminary. r Revised.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Index of Output per Man-hour Selected Industries, 1973 edition. BLS Bull. 1780, 1973, tables 2, 4, 6, 8, 12, and 42.

Table 29.—Index of average unit mine value of minerals produced

(1967=100)

	1969	1970	1971	1972	1973 p
METALS					
Ferrous	104.1	109.4	115.9	120.2	125.5
Nonferrous:					
Base	120.0	141.9	129.9	130.7	151.1
Monetary	118.0	109.1	108.8	138.1	222.3
Other	95.4	129.1	130.0	131.2	134.5
Average	115.3	136.4	127.8	131.5	155.1
Average all metals	109.4	122.1	121.5	125.5	139.4
NONMETALS					
Construction	103.5	107.8	112.7	120.8	126.2
Chemical	97.9	87.2	86.2	85.2	91.1
Other	111.2	108.5	115.7	123.4	132.6
Average	102.6	103.2	106.9	113.0	118.6
FUELS					
Coal	108.0	135.4	152.9	165.2	183.3
Crude oil and natural gas	107.9	108.5	115.6	116.4	133.8
Average	106.1	111.8	120.6	123.4	141.6
Overall average	105.6	110.7	117.6	121.2	136.3

p Preliminary.

Table 30.—Index of implicit unit value of minerals produced

(1967=100)

	1969	1970	1971	1972	1973 p
METALS					
Ferrous	104.1	109.1	115.6	119.5	123.7
Nonferrous:					
Base	120.4	143.4	130.1	130.6	151.0
Monetary	118.0	109.5	r 107.9	136.2	212.2
Other	95.6	129.7	132.0	136.4	138.9
Average	117.7	139.8	128.7	131.4	153.1
Average all metals	112.4	128.7	124.1	127.3	141.9
NONMETALS					
Construction	103.0	107.7	112.8	120.6	126.0
Chemical	97.8	87.4	86.9	84.6	90.3
Other	111.0	108.8	115.2	119.8	128.0
Average	102.3	103.2	107.3	112.5	118.6
FUELS					
Coal	108.0	135.4	152.9	165.5	183.5
Crude oil and natural gas	107.9	108.5	115.5	116.4	134.0
Average	106.0	111.5	119.8	129.2	141.5
Overall average	105.9	111.8	117.6	121.2	136.2

p Preliminary. r Revised.

Table 31.—Price indexes for selected metals, minerals, and fuels

(1967=100)

Commodity	Annual average 1972	Annual average 1973	Percent change from 1972
Metals and metal products	123.5	132.8	+7.5
Iron and steel	128.4	136.2	+6.1
Iron ore	103.0	106.7	+3.6
Iron and steel scrap	121.8	188.0	+54.4
Semifinished steel products	130.9	133.9	+2.3
Finished steel products	130.4	134.1	+2.8
Foundry and forge shop products	124.3	131.5	+5.8
Pig iron and ferroalloys	125.4	129.4	+3.2
Nonferrous metals	116.9	135.0	+15.5
Primary metal refinery shapes	115.6	139.1	+20.3
Aluminum ingot	96.9	101.5	+4.7
Lead, pig, common	109.6	117.0	+6.8
Zinc, slab, prime western	123.4	146.7	+18.9
Nonferrous scrap	r 102.9	148.4	+44.2
Nonmetallic mineral products	126.1	130.2	+3.3
Concrete ingredients	126.9	131.2	+3.4
Sand, gravel, and crushed stone	121.7	125.0	+2.7
Structural clay products	117.3	123.3	+5.1
Gypsum products	114.7	120.9	+5.4
Other nonmetallic minerals	127.0	128.4	+1.1
Building lime	121.9	126.9	+4.1
Insulation materials	136.9	137.4	+.4
Bituminous binders	123.9	126.2	+1.9
Fertilizer materials	74.4	77.1	+3.6
Nitrogenates	r 71.3	75.5	+5.9
Phosphates	75.0	75.0	--
Phosphate rock	79.8	79.8	--
Potash	100.4	105.7	+5.3
Muriate, domestic	99.7	104.7	+5.0
Sulfate	104.1	110.9	+6.5
Fuels and related products and power	118.6	145.5	+22.7
Coal	193.8	218.1	+12.5
Anthracite	151.1	166.9	+10.5
Bituminous	197.4	222.5	+12.7
Coke	155.5	166.6	+7.1
Gas fuels	114.1	126.7	+11.0
Electric power	121.5	129.3	+6.4
Petroleum products, refined	108.9	151.4	+39.0
Crude petroleum [1]	113.8	126.0	+10.7
All commodities other than farm and food	117.9	127.0	+7.7
All commodities	119.1	135.5	+13.8

r Revised.
[1] Includes only domestic production.

Source: U.S. Department of Labor, Bureau of Labor Statistics, Wholesale Prices and Price Indexes. January–December 1972, table 6; July 1974, table 4.

Table 32.—Comparative mineral energy resource prices

Fuel		1971	1972	1973
Bituminous coal: Average prices:				
Cost of coal at merchant coke ovens	dollars per net ton	15.32	17.67	19.77
Anthracite, average sales realization per net ton at preparation plants, excluding dredge coal:				
Chestnut	dollars	16.79	17.66	19.30
Pea	do	15.28	15.72	16.98
Buckwheat No. 1	do	14.83	15.38	16.61
Petroleum and petroleum products:				
Crude petroleum, average price per barrel at well	do	3.39	3.39	3.89
Gasoline, average dealers' net price (excluding taxes) of gasoline in 55 U.S. cities [1]	cents per gallon	18.11	17.72	19.48
Residual fuel oil:				
No. 6 fuel, maximum 1% sulfur, at Philadelphia [1]	dollars per barrel (refinery)	4.21	[2] 4.08	3.89
Bunker C, average price for all gulf ports [1]	do	2.81	2.05	3.42
Distillate fuel oil:				
No. 2 distillate, average of high and low prices at Philadelphia [1]	cents per gallon (refinery)	11.78	11.75	13.41
No. 2 distillate, average price for all gulf ports [1]	do	9.80	10.10	20.65
Natural gas:				
Average U.S. value at well	cents per thousand cubic feet	18.2	18.6	21.6
Average U.S. value at point of consumption	do	57.7	62.1	66.5

[1] Platt's Oil Price Handbook.
[2] Erroneously reported in 1972 table.

Table 33.—Cost of fuel in steam-electrical power generation

(Cents per million Btu)

Region	1970 Coal	1970 Oil	1970 Gas	1971 Coal	1971 Oil	1971 Gas	1972 Coal	1972 Oil	1972 Gas
New England	41.9	32.8	35.3	48.8	47.6	45.5	49.7	55.5	46.1
Middle Atlantic	36.1	40.2	38.3	40.9	57.1	44.9	42.1	62.3	53.1
East North-Central	30.4	56.7	37.1	35.5	63.2	42.9	38.9	68.0	51.6
West North-Central	28.2	59.0	25.6	31.6	70.3	28.3	34.0	69.9	29.9
South Atlantic	36.1	31.9	34.7	41.8	43.3	39.7	42.6	49.6	39.9
East South-Central	23.6	54.1	25.3	29.2	49.6	27.9	32.5	72.4	29.9
West South-Central	40.1	44.6	21.1	17.8	59.8	22.2	21.0	67.2	24.2
Mountain	19.8	28.2	29.3	20.9	40.4	32.4	22.7	58.2	35.1
Pacific	--	36.8	32.4	--	55.4	34.6	--	73.9	37.5
United States	31.1	36.6	27.0	36.0	51.5	28.8	38.2	58.8	30.3

Source: National Coal Association. Steam-Electric Plant Factors. 1971, 1972, and 1973, table 2.

Table 34.—Cost of electrical energy

(Cents per kilowatt-hour)

Region	1970 Total	1970 Residential	1970 Commercial and industrial	1971 Total	1971 Residential	1971 Commercial and industrial	1972 Total	1972 Residential	1972 Commercial and industrial
New England	2.2	2.6	1.9	2.3	2.7	2.0	2.5	2.9	2.2
Middle Atlantic	1.9	2.6	1.6	2.2	2.9	1.9	2.4	3.0	2.0
East North-Central	1.7	2.3	1.4	1.8	2.4	1.5	1.9	2.5	1.7
West North-Central	2.0	2.4	1.7	2.0	2.5	1.7	2.1	2.5	1.9
South Atlantic	1.6	1.9	1.3	1.6	2.0	1.4	1.8	2.1	1.5
East South-Central	1.0	1.4	.9	1.2	1.5	1.0	1.2	1.6	1.0
West South-Central	1.5	2.1	1.2	1.5	2.1	1.2	1.5	2.2	1.2
Mountain	1.5	2.1	1.2	1.5	2.1	1.3	1.6	2.2	1.4
Pacific	1.2	1.7	1.1	1.3	1.7	1.1	1.4	1.8	1.2
Alaska and Hawaii	2.4	2.8	2.1	2.5	2.9	2.2	2.6	3.0	2.3
United States	1.6	2.1	1.3	1.7	2.2	1.4	1.8	2.3	1.5

Source: Edison Electric Institute. Statistical Yearbook of the Electric Utilities Industry. 1970, 1971, and 1972, based on tables 22–S and 36–S.

Table 35.—Price index of principal metal mining expenses[1]
(1967=100)

Year	Total	Labor	Supplies	Fuel	Electrical energy
1969	104	104	106	101	102
1970	109	108	111	106	105
1971	114	113	116	114	114
1972	120	120	120	119	122
1973 p	128	126	128	146	129

p Preliminary.
[1] Indexes constructed using the following weights derived from the 1967 Census of Mineral Industries: Labor, 50.04; explosives, 3.18; steel mill shapes and forms, 7.32; all other supplies, 26.89; fuels, 5.88; electric energy, 6.69; and data from U.S. Department of Labor, Bureau of Labor Statistics, Wholesale Prices and Price Indexes. The index is computed for iron and copper ores only because sufficient data are not available for other mining sectors.

Table 36.—Index of major input expenses for bituminous coal and crude petroleum and natural gas mining[1]
(1967=100)

Year	Bituminous coal	Crude petroleum and natural gas
1969	108	105
1970	r 119	108
1971	r 129	114
1972	141	NA
1973 p	158	NA

p Preliminary. r Revised. NA Not available.
[1] Indexes constructed by using data from the U.S. Department of Labor, Bureau of Labor Statistics, Wholesale Prices and Price Indexes, annual and monthly, and weights derived from data shown in the 1967 Census of Mineral Industries, U.S. Department of Commerce, Bureau of the Census. Weights used are as follows: Bituminous coal—labor, 61.55; explosives, 2.70; steel mill shapes and forms, 5.08; all other supplies, 24.58; fuels, 1.74; electric energy, 4.35; crude petroleum and natural gas—labor, 44.65; supplies, 48.79; fuel, 2.07; and electric energy, 4.49.

Table 37.—Indexes of relative costs and productivity for iron ore, copper, bituminous coal, and petroleum mining[1]

(1967=100)

Year	Iron ore[2]	Copper[2]	Bituminous coal	Petroleum
INDEX OF LABOR COSTS PER UNIT OF OUTPUT				
1969	102	105	109	105
1970	109	107	r 125	107
1971	115	111	r 138	114
1972	112	126	154	NA
1973 p	111	144	175	NA
INDEX OF VALUE OF PRODUCT PER MAN-PERIOD				
1969	110	135	112	114
1970	111	170	133	124
1971	115	155	144	132
1972	129	149	153	NA
1973 p	142	161	161	NA
INDEX OF LABOR COSTS PER DOLLAR OF PRODUCT				
1969	102	83	101	99
1970	107	71	92	99
1971	110	82	r 90	99
1972	106	95	93	NA
1973 p	99	93	95	NA

p Preliminary. r Revised. NA Not available.

[1] Index of labor costs per unit of output: Iron ore and copper indexes are computed from data found in U.S. Department of Labor, Employment and Earnings and Wholesale Price Indexes. Bituminous coal index based upon net tons per man per day (see chapter on Bituminous Coal) and index of average earnings derived from Bureau of Labor Statistics data on hourly earnings; petroleum index based on barrels per year (see chapter on Petroleum) and Bureau of Employment Security data on total wages in petroleum production.

Index of value of product per man-period: Iron ore and copper indexes are computed from data found in U.S. Department of Labor, Employment and Earnings and Wholesale Price Indexes. Bituminous coal index based on net tons per man per day and mine value of production; petroleum index based on average employment and total value of production.

Index of labor costs per dollar of product: Iron ore and copper indexes are computed from data found in U.S. Department of Labor, Employment and Earnings and Wholesale Price Indexes. Bituminous coal index based on index of value per man per day and index of average earnings; petroleum index based on total value of production and total wages.

[2] Indexes are for recoverable metal.

Table 38.—Price indexes for selected cost items in minerals and mineral fuels production

(1967=100)

Commodity	1973		Change from January percent	Annual average		Change from 1972 percent
	January	December		1972	1973	
Coal	205.5	240.7	+17.1	193.8	218.1	+12.5
Coke	162.5	170.0	+4.6	155.5	166.6	+7.1
Gas fuels	118.4	137.6	+16.2	114.1	126.7	+11.0
Petroleum products, refined	112.3	252.0	+124.4	108.9	151.4	+39.0
Industrial chemicals	101.4	105.9	+4.4	101.2	103.4	+2.2
Lumber	169.0	214.8	+27.1	159.4	205.2	+28.7
Explosives	117.9	129.0	+9.4	115.2	120.1	+4.3
Construction machinery and equipment	126.6	134.1	+5.9	125.7	130.7	+4.0

Source: U.S. Department of Labor, Bureau of Labor Statistics. Wholesale Prices and Price Indexes. January and December 1973, Supplement 1973 and 1974, table 5.

Table 39.—Price indexes for mining construction and material handling machinery and equipment

(1967=100)

Year	Construction machinery and equipment	Mining machinery and equipment	Oilfield machinery and tools	Power cranes, draglines, shovels, etc.	Specialized construction machinery	Portable air compressors	Scrapers and graders	Mixers, pavers, spreaders, etc.	Tractors other than farm
1969	110.4	106.6	112.7	109.0	110.2	91.8	110.1	109.1	112.5
1970	115.5	110.5	118.4	114.0	117.4	93.7	115.2	116.0	116.7
1971	121.4	113.8	122.6	120.6	125.1	93.8	120.6	122.9	122.3
1972	125.7	117.2	127.3	126.0	129.0	92.0	124.4	126.3	127.3
1973	130.7	121.1	133.2	130.5	134.1	93.5	136.1	130.4	131.5

Source: U.S. Department of Labor, Bureau of Labor Statistics. Wholesale Prices and Price Indexes. January 1970–71, table 2–A; January–December 1972 and 1973, table 6.

Table 40.—National income originated in the mineral industries

Industry	Income, million dollars 1971 r	1972	1973 p	Change from 1972 percent
Mining	7,056	8,253	9,397	+13.9
Metal mining	932	983	1,210	+23.1
Coal mining	2,074	2,233	2,411	+8.0
Crude petroleum and natural gas	2,613	3,508	4,006	+14.2
Mining and quarrying of nonmetallic minerals	1,437	1,529	1,770	+15.8
Manufacturing	226,470	253,352	287,237	+13.4
Chemicals and allied products	17,021	18,503	21,032	+13.7
Petroleum refining and related industries	7,729	8,196	9,364	+14.3
Stone, clay, and glass products	7,561	8,629	9,867	+14.3
Primary metal industries	15,078	18,453	22,025	+19.4
All industries	857,683	946,534	1,065,590	+12.6

p Preliminary. r Revised.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 54, No. 7, July 1974, p. 17, table 1.12.

Table 41.—Annual average profit rates on shareholders' equity, after taxes, and total dividends, selected mineral manufacturing corporations

Industry	Annual profit rate percent			Total dividends (million dollars)		
	1972	1973	Change from 1972	1972	1973	Change from 1972 percent
All manufacturing	10.6	12.8	+2.2	r 16,110	17,767	+10.3
Primary metals	6.0	10.1	+4.1	r 832	1,101	+32.3
Primary iron and steel	r 6.0	9.5	+3.5	r 461	559	+21.3
Primary nonferrous metals	5.9	10.8	+4.9	370	543	+46.8
Stone, clay, and glass products	10.1	11.2	+1.1	415	447	+7.7
Chemicals and allied products	r 12.8	14.8	+2.0	r 2,152	2,354	+9.4
Petroleum refining and related industries	8.7	11.6	+2.9	3,325	3,452	+3.8
Petroleum refining	r 8.7	11.6	+2.9	r 3,317	3,445	+3.9

r Revised.

Source: Federal Trade Commission. Quarterly Financial Report for Manufacturing Corporations. 1st and 4th Quarter 1973, tables 4 and 8.

Table 42.—Industrial and commercial failures and liabilities in mining and manufacturing

Industry	1971	1972	1973
Mining:[1]			
Number of failures	38	44	32
Current liabilities ----thousands--	$15,463	$11,907	$23,866
Manufacturing:			
Number of failures	1,894	1,532	1,431
Current liabilities ----thousands--	$697,148	$755,084	$733,624
All industrial and commercial industries:			
Number of failures	10,326	9,566	9,345
Current liabilities ----thousands--	$1,916,929	$2,000,244	$2,298,606

[1] Including fuels.

Source: Dun and Bradstreet, Inc. Business Economics Department. Monthly Failure Report, K-15, No. 12, Jan. 30, 1973; K-15, No. 12, Feb. 14, 1974.

Table 43.—Expenditures for new plant and equipment by firms in mining and selected mineral manufacturing industries

(Billion dollars)

Industry	1971	1972	1973 p
Mining[1]	2.16	2.42	2.76
Manufacturing:			
Primary iron and steel	1.37	1.24	1.41
Primary nonferrous metals	1.08	1.18	1.68
Stone, clay, and glass products	.85	1.20	1.50
Chemical and allied products	3.44	3.45	4.32
Petroleum and coal products	5.85	5.25	5.41
All manufacturing	29.99	31.35	38.00

p Preliminary.
[1] Including fuels.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 52, No. 3, March 1972, p. 20, table 8; v. 54, No. 1, January 1974, p. 11, table 1.

Table 44.—Plant and equipment expenditures of foreign affiliates of U.S. companies, by area and industry[1]

(Million dollars)

Area or country	1971			1972			1973		
	Mining and smelting	Petroleum	Manufacturing	Mining and smelting	Petroleum	Manufacturing	Mining and smelting	Petroleum	Manufacturing
Canada	827	698	1,153	719	804	1,452	534	878	1,659
Latin America	209	667	648	174	624	880	187	610	1,007
Europe	5	1,406	4,260	5	1,365	3,830	3	1,506	4,071
All other areas	424	2,188	1,045	351	2,557	961	537	3,186	1,006
Total	1,465	4,959	7,106	1,249	5,350	7,123	1,261	6,180	7,743

[1] Series revised back to 1966; see source for details.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 53, No. 12, December 1973, pp. 29–31.

Table 45.—Estimated gross proceeds of new corporate securities offered for cash in 1973[1]

Type of security	Total corporate		Manufacturing		Extractive[2]	
	Million dollars	Percent	Million dollars	Percent	Million dollars	Percent
Bonds	22,251	66.6	4,241	86.8	232	21.6
Preferred stock	3,383	10.1	107	2.2	10	.9
Common stock	7,800	23.3	537	11.0	831	77.5
Total	33,434	100.0	4,885	100.0	1,073	100.0

[1] Substantially all new issues of securities offered for cash sale in the United States in amounts over $100,000 and with terms of maturity of more than 1 year are covered in these data.
[2] Including fuels.

Source: U.S. Securities and Exchange Commission. Statistical Bulletin. V. 33, No. 9, Feb. 27, 1974, pp. 253–254.

Table 46.—Direct private investment of U.S. companies in foreign petroleum industries in 1972 p

(Million dollars; net inflows to the United States designated by—)

	Petroleum				All industries			
	Book value beginning of year	Net capital outflows	Undistributed earnings of subsidiaries	Book value end of year	Book value beginning of year	Net capital outflows	Undistributed earnings of subsidiaries	Book value end of year
Developed countries [1]	12,958	701	571	14,200	58,571	1,897	3,668	64,114
Canada	5,149	—92	314	5,311	24,105	380	1,367	25,784
Europe	6,192	627	165	6,992	27,740	1,074	1,885	30,714
Japan	637	89	47	796	1,821	200	171	2,222
Australia, New Zealand, and South Africa, Republic of	980	77	45	1,102	4,904	244	245	5,393
Developing countries [1]	9,148	682	69	9,878	23,358	1,117	749	25,186
Latin American Republics and other Western Hemisphere	4,195	28	46	4,267	15,789	279	600	16,644
Other Africa	2,094	88	74	2,254	2,871	123	96	3,086
Middle East	1,464	371	—27	1,807	1,661	399	—8	2,053
Other Asia and Pacific	1,396	195	—25	1,550	3,036	316	61	3,402
International, unallocated	2,045	251	28	2,321	4,270	391	104	4,733
Total [1]	24,152	1,635	668	26,399	86,198	3,404	4,521	94,031

p Preliminary.
[1] Data may not add to totals shown because of independent rounding.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 53, No. 9, September 1973, pp. 24–28.

Table 47.—Direct private investments of the United States in foreign mining and smelting industries in 1972 p

(Million dollars)

	Book value at yearend	Net capital outflows	Undistributed earnings of subsidiaries	Earnings [1]	Income [2]
Developed countries [3]	4,420	354	25	235	213
Canada	3,490	240	6	139	131
Europe	79	—2	(4)	(4)	(4)
Australia, New Zealand, South Africa, Republic of	851	117	18	94	80
Australia	707	94	13	68	61
South Africa, Republic of	136	22	5	26	18
Developing countries [3]	2,712	57	9	182	186
Latin American Republics, total	1,300	—46	—1	64	74
Mexico	124	—11	7	9	2
Panama	19	--	--	--	--
Brazil	136	(4)	(4)	(4)	(4)
Chile	359	—92	(4)	(4)	(4)
Peru	416	12	1	26	25
Other Western Hemisphere	782	31	(4)	94	98
Other Africa	425	24	10	24	13
Middle East	5	3	(4)	(4)	(4)
Other Asia and Pacific	199	45	(4)	(4)	1
Total [3]	7,131	411	34	418	399

p Preliminary.
[1] Earnings is the sum of the U.S. share in net earnings of subsidiaries and branch profits.
[2] Income is the sum of dividends, interest, and branch profits.
[3] Data may not add to totals shown because of independent rounding.
[4] Combined in "other industries" in source reference.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 53, No. 9, September 1973, p. 26.

Table 48.—Value of foreign direct investments in the United States

(Million dollars)

Industry	1968	1969	1970	1971	1972 p
Total	10,815	11,818	13,270	13,655	14,363
Petroleum	2,261	2,493	2,992	3,113	3,243

p Preliminary.

Source: U.S. Department of Commerce, Bureau of Economic Analysis. Survey of Current Business. V. 53, No. 2, February 1973, p. 30; v. 53, No. 8, August 1973, p. 50.

Table 49.—Railroad and water transportation of selected minerals and mineral energy products in the United States

(Thousand short tons)

Products	Rail[1] 1971	Rail[1] 1972	Rail[1] Change from 1971 percent	Water[2] 1971	Water[2] 1972	Water[2] Change from 1971 percent
Metals and minerals except fuels:						
Iron ore and concentrates	91,267	90,150	−1.2	68,042	73,453	+8.0
Iron and steel scrap	26,609	17,617	−33.8	1,505	1,729	+14.9
Pig iron	3,534	2,403	−32.0	395	339	−14.2
Iron and steel ingot, plates, rods, bars, tubing, and other primary products	42,356	38,932	−8.1	8,291	8,881	+7.1
Bauxite and other aluminum ores and concentrates	[3] 4,552	422	−90.7	396	75	−81.1
Other nonferrous ores and concentrates	14,584	15,281	+4.8	2,181	1,517	−30.4
Nonferrous metals and alloys	9,619	10,580	+10.0	651	632	−2.9
Nonferrous metal scrap	2,305	2,660	+15.4	93	64	−31.2
Slag	2,232	2,082	−6.7	751	1,165	+55.1
Sand and gravel	50,156	52,521	+4.8 }	82,649	80,356	−2.8
Stone, crushed and broken	57,273	58,031	+1.3 }			
Limestone flux and calcareous stone	--	9,889	XX	30,819	31,613	+2.6
Cement, building	20,781	21,387	+2.9	10,793	10,634	−1.5
Lime	6,094	6,600	+8.3	749	992	+32.4
Phosphate rock	33,267	36,442	+9.5	7,209	8,762	+21.5
Clays, ceramic and refractory materials	2,961	3,257	+10.0	1,757	1,489	−15.3
Sulfur, dry }	2,883	3,894	+35.1	44	59	+34.1
Sulfur, liquid }				8,300	9,028	+8.8
Gypsum and plaster rock	648	704	+8.6	864	963	+11.5
Other nonmetallic minerals except fuels	10,647	4,378	−58.9	7,692	7,075	−8.0
Fertilizer and fertilizer materials	19,134	19,284	+.8	6,538	6,943	+6.2
Total	400,902	396,514	−1.1	239,719	245,769	+2.5
Mineral energy resources and related products:						
Coal:						
Anthracite	5,601	3,835	−31.5 }	140,053	148,994	+6.4
Bituminous and lignite	354,954	371,135	+4.6 }			
Coke	1,528	1,231	−19.4	1,034	1,186	+14.7
Crude petroleum	457	1,028	+124.9	114,721	103,673	−9.6
Gasoline						
Jet fuel }	1,660	214	−87.1	{93,514	93,615	+.1
Kerosine }				{13,682	13,173	−3.7
Distillate fuel oil	132	51	−61.4	5,963	6,089	+2.1
Residual fuel oil	1,316	355	−73.0	78,216	85,328	+9.1
Asphalt, tar, and pitches	4,797	3,027	−36.9	89,083	102,209	+14.7
Liquefied petroleum gases and coal gases	2,048	2,985	+45.8	8,414	9,176	+9.1
Other petroleum and coal products[4]	7,201	7,001	−2.8	1,083	1,537	+41.9
Total	16,523	20,950	+26.8	12,116	11,805	−2.6
	396,217	411,812	+3.9	557,879	576,785	+3.4
Total mineral products	797,119	808,326	+1.4	797,598	822,554	+3.1
Grand total, all commodities	1,390,960	1,447,864	+4.1	946,598	986,812	+4.2
Mineral products, percent of grand total:						
Metals and minerals except fuels	28.8	27.4	−4.9	25.3	24.9	−1.6
Mineral energy resources and related products	28.4	55.8	+1.4	58.9	58.4	−.8
Total mineral products[5]	57.3	56.2	−1.9	84.3	83.4	−1.1

XX Not applicable.

[1] Revenue freight originated on respondent's road and terminated on line by originating carrier or delivered to connecting rail carrier.

[2] Domestic traffic includes all commercial movements between points in the United States, Puerto Rico, and the Virgin Islands.

[3] Corrected figure.

[4] Includes lubricants, naphtha, and other petroleum solvents, and miscellaneous petroleum and coal products.

[5] Data may not add to totals shown because of independent rounding.

Source: Interstate Commerce Commission. Bureau of Accounts. Freight Commodity Statistics. Class I Railroads in the United States for the Years Ended December 31, 1971 and 1972, Department of the Army, Corps of Engineers, Waterborne Commerce of the United States, Part 5. National Summaries, Calendar Years 1971 and 1972, table 2.

Table 50.—Percentage distribution of mine shipments of bituminous coal and lignite by method of shipment and mine use

Year	Shipped by rail and trucked to rail	Shipped by water and trucked to water	Trucked to final destination	Used at mines [1]	Total production
1969	71.0	12.7	11.8	4.5	100.0
1970	68.1	13.5	12.0	6.4	100.0
1971	69.2	10.7	10.9	9.2	100.0
1972	66.2	11.7	11.0	11.1	100.0
1973	67.1	11.5	9.8	11.6	100.0

[1] Includes coal used at mine for power and heat, made into beehive coke at mine, used by mine employees, used for all other purposes at mine, and transported from mine to point of use by conveyor, tram, or pipeline.

Table 51.—Miles of utility gas main, by type of main [1]

(Thousands)

Type of main	1968	1969	1970	1971	1972
Field and gathering	64.4	64.9	66.6	66.5	67.1
Transmission	234.5	248.1	252.6	r 256.5	260.2
Distribution	562.7	578.6	595.6	r 610.7	623.9
Total	861.6	891.6	914.8	r 933.7	951.2

r Revised.
[1] Excludes service pipe. Data not adjusted to common diameter equivalent. Mileage shown as of end of each year.

Source: American Gas Association. Gas Facts, a Statistical Record of the Gas Utility Industry in 1972, p. 50.

Table 52.—Petroleum pipelines, selected years

(Miles)

Year	Trunklines		Gathering lines	Total
	Crude	Products		
1959	70,317	44,483	75,182	189,982
1962	70,355	53,200	76,988	200,543
1965	72,383	61,443	77,041	210,867
1968	70,825	64,529	74,124	209,478
1971	75,066	72,406	71,132	218,604

Table 53.—Research and development activity

(Million dollars)

	Total			Funds expended: Company			Funds expended: Federal Government		
	1970	1971	1972	1970	1971	1972	1970	1971	1972
Petroleum refining and extraction	608	505	475	565	488	462	43	17	15
Percent of all industries	3.4	2.7	2.4	5.6	4.5	4.1	0.6	0.2	0.2
Chemicals and allied products	1,812	1,822	1,913	1,624	1,639	1,719	188	183	196
Percent of all industries	10.1	9.9	9.8	16.1	15.2	15.3	2.4	2.4	2.4
All industries	17,858	18,420	19,521	10,073	10,749	11,247	7,785	7,671	8,274

Source: National Science Foundation. Research and Development in Industry. NSF 72-309, April 1972, table 2. National Science Foundation. Science Resources Studies Highlights. NSF 73-317, Dec. 31, 1973, p. 3.

Table 54.—Federal obligated funds for metallurgy and materials research

(Thousand dollars)

Federal agency	Fiscal year 1973 ᵉ			Fiscal year 1974 ᵉ		
	Basic research	Applied research	Total research	Basic research	Applied research	Total research
Department of Defense	33,158	68,750	101,908	33,734	73,080	106,814
Atomic Energy Commission	10,982	15,600	26,582	12,129	15,900	28,029
National Aeronautic and Space Administration	6,863	45,926	52,789	6,535	44,570	51,105
Bureau of Mines	324	17,406	17,730	298	16,145	16,443
National Science Foundation	9,210	520	9,730	9,590	890	10,480
Department of Commerce	705	1,582	2,287	714	1,535	2,249
Federal Highway Administration	--	1,738	1,738	--	2,289	2,289
Other	11	1,387	1,398	--	1,122	1,122
Total	61,253	152,909	214,162	63,000	155,531	281,531

ᵉ Estimate.

Source: National Science Foundation. Federal Funds for Research Development, and Other Scientific Activities, Fiscal Years 1972, 1973, and 1974. Detailed Statistical Tables C–24, C–25, C–43, C–44, C–62, C–63.

Table 55.—Bureau of Mines obligations for mining and mineral research and development

(Thousand dollars)

Fiscal year	Applied research	Basic research	Development	Total
1970	27,646	6,248	12,563	46,457
1971	32,214	6,525	21,561	60,300
1972	32,805	7,846	30,237	70,888
1973	34,591	6,863	36,053	77,507
1974 ᵉ	44,417	7,552	38,160	90,129

ᵉ Estimate.

Table 56.—Bureau of Mines obligations for total research by field of science

(Thousand dollars)

	Fiscal year		
	1972	1973	1974 ᵉ
Engineering sciences	28,733	30,490	38,050
Physical sciences	10,525	9,263	10,661
Mathematical sciences	529	555	1,092
Environmental sciences	864	1,146	2,166
Total	40,651	41,454	51,969

ᵉ Estimate.

Table 57.—Summary of Government inventories of strategic and critical materials, December 31, 1973

	Acquisition cost	Market value [1]
Total inventories in storage:		
National stockpile	$3,420,829,900	$5,612,408,700
Supplemental stockpile	1,288,714,100	1,502,197,400
Defense Production Act	510,142,400	285,499,200
Total on hand	5,219,686,400	7,400,105,300
Inventories within objective: Total on hand	525,818,000	868,632,000
Inventories excess to objective: Total on hand	4,693,868,400	6,531,473,300

[1] Market values are computed from prices at which similar materials are being traded, or in the absence of current trading, at an estimate of the price which would prevail in commercial markets. Prices used are unadjusted for normal premiums and discounts relating to contained qualities, or for inherent materials-handling allowances. Market values do not necessarily reflect the amount that would be realized at time of sale. The uncommitted excess excludes the unshipped sales; the inventories in storage include quantities that have been sold but not shipped.

Source: General Services Administration, Office of Preparedness. Stockpile Report to the Congress. July–December 1973, p. 2.

Table 58.—U.S. Government stockpile disposal of mineral commodities, 1973

Commodity	Sales commitments: Quantity	Sales commitments: Sales value
NATIONAL AND SUPPLEMENTAL STOCKPILE INVENTORIES		
Aluminum ---short tons--	570,374	$287,074,032
Aluminum oxide ---do---	57,193	6,030,143
Antimony ---do---	5,973	7,698,604
Asbestos, amosite ---do---	109	23,030
Asbestos, chrysotile ---do---	107	18,800
Asbestos, crocidolite ---do---	6,927	1,454,670
Cadmium ---pounds--	770,405	2,486,284
Celestite ---short dry tons--	12,062	423,014
Chromite, chemical ---do---	19	20,360
Chromite, metallurgical ---do---	39,931	304,414
Chromite, refractory ---do---	191,000	4,149,800
Chromium metal ---short tons--	1,056	2,382,864
Cobalt ---pounds--	7,435,592	20,358,824
Columbium ores and concentrates ---do---	822,486	1,385,202
Columbium, ferro ---do---	457,515	1,054,744
Columbium, oxide powder ---do---	85,826	207,031
Diamond, industrial bort ---carats--	2,489,500	5,756,791
Diamond, industrial stones ---do---	830,000	9,089,749
Kyanite—mullite ---short dry tons--	2,004	160,320
Lead ---short tons--	248,539	75,013,685
Magnesium ---do---	66,638	41,670,507
Manganese, battery grade, synthetic dioxide ---short dry tons--	681	195,033
Manganese, chemical-type B ---do---	600	38,430
Manganese, metallurgical ---do---	2,242,413	52,459,946
Manganese, ferro-high-carbon ---short tons--	342,148	50,739,754
Manganese metal, electrolytic ---do---	1,942	1,082,984
Mica, muscovite block ---pounds--	1,360,374	761,203
Mica, muscovite film ---do---	7,385	9,800
Mica, muscovite splittings ---do---	1,319,372	526,342
Mica, phlogopite splittings ---do---	506,748	403,720
Molybdenum disulfide ---do---	[1] —1,668,000	[1] —3,578,984
Molybdenum, ferro ---do---	2,521,000	4,961,140
Molybdenum, oxide ---do---	2,399,000	4,016,140
Quartz, crystals ---do---	645,532	1,804,711
Rare earths ---short dry tons--	2,529	1,170,475
Selenium ---pounds--	329,790	3,195,819
Talc, steatite, ground ---short tons--	510	4,930
Thorium nitrate ---pounds--	54,944	108,419
Tin ---long tons--	19,511	105,554,352
Tungsten ores and concentrates ---pounds--	1,497,804	4,520,896
Vanadium ---short tons	1,200	8,503,755
Zinc ---do---	266,315	98,021,821
Zirconium ore, baddeleyite ---short dry tons--	15,999	43,997
Total ---	--	801,307,551
DEFENSE PRODUCTION ACT (DPA) INVENTORY		
Aluminum ---short tons--	236,741	121,185,754
Cobalt ---pounds--	614,927	1,668,173
Columbium ores and concentrates ---do---	228,063	420,970
Manganese, battery grade, synthetic dioxide ---short dry tons--	1,000	340,153
Manganese, metallurgical ---do---	479,588	9,224,720
Manganese metal, electrolytic ---short tons--	5,409	3,907,079
Mica, muscovite block ---pounds--	470,827	475,701
Rutile ---short dry tons--	13,756	2,747,474
Tantalum minerals ---pounds--	217,203	2,121,846
Titanium ---short tons--	3,705	7,549,346
Total ---	--	149,641,216
OTHER		
Bauxite ---long dry tons--	110,000	500,000
Lithium ---pounds--	1,900,000	918,712
Mercury ---flasks--	2,583	724,503
Zirconium metal powder ---pounds--	2,000	1,000
Total ---	--	2,144,215
Grand total ---	--	953,092,982

[1] Negative figure represents adjustment of sales contract in a previous report period.

Source: General Services Administration, Office of Preparedness. Stockpile Report to the Congress. January–June 1973, pp. 16–17; July–December 1973, pp. 14–15.

Table 59.—United Nations' indexes of world [1] mineral industry production

(1963=100)

Industry sector and geographic area	1971	1972	1973	1973 by quarters 1st	2nd	3d	4th
EXTRACTIVE INDUSTRIES							
Metals:							
Non-Communist world	134	132	138	134	140	137	140
Industrialized countries [2]	133	129	136	131	140	135	139
United States and Canada	129	126	138	127	144	140	140
Europe	126	126	127	130	131	116	131
European Economic Community [3]	86	83	77	88	76	68	75
European Free Trade Association [4]	149	146	153	160	162	127	163
Australia and New Zealand	206	214	222	202	224	220	242
Less industrialized countries [5]	136	136	141	139	140	139	143
Latin America [6]	141	143	147	141	148	146	152
Asia [7]	143	143	147	149	147	143	150
Communist Europe [8]	202	213	229	232	227	229	226
World	149	150	158	156	160	157	159
Coal:							
Non-Communist world	87	82	82	87	82	77	81
Industrialized countries [2]	85	79	78	83	79	74	78
United States and Canada	117	123	123	122	121	122	128
Europe	73	62	62	69	63	56	60
European Economic Community [3]	71	60	60	68	61	54	58
European Free Trade Association [4]	61	61	59	64	57	59	57
Australia and New Zealand	159	172	177	159	180	195	172
Less industrialized countries [5]	124	126	129	134	130	126	127
Latin America [6]	152	150	151	NA	NA	NA	NA
Asia [7]	121	122	126	130	128	123	125
Communist Europe [8]	128	130	135	137	132	132	137
World	104	102	104	108	103	100	105
Crude petroleum and natural gas:							
Non-Communist world	175	188	199	197	196	202	201
Industrialized countries [2]	141	151	151	158	148	147	154
United States and Canada	131	136	136	137	134	135	138
Europe	276	321	342	395	324	291	357
European Economic Community [3]	318	376	398	469	376	333	416
European Free Trade Association [4]	NA	NA	NA	NA	NA	NA	NA
Australia and New Zealand [9]	--	--	--	--	--	--	--
Less industrialized countries [5]	210	226	248	239	246	258	249
Latin America [6]	118	112	116	113	116	118	118
Asia [7]	225	254	294	281	287	311	295
Communist Europe [8]	187	198	212	215	214	211	208
World	178	190	202	201	200	204	203
Total extractive industry:							
Non-Communist world	144	148	157	155	157	157	159
Industrialized countries [2]	122	123	127	127	127	124	129
United States and Canada	127	131	135	132	135	135	138
Europe	108	105	109	116	110	101	110
European Economic Community [3]	104	101	104	113	105	96	104
European Free Trade Association [4]	128	125	131	134	135	119	137
Australia and New Zealand	176	184	190	172	192	197	200
Less industrialized countries [5]	190	202	221	214	219	227	223
Latin America [6]	125	122	126	121	125	126	NA
Asia [7]	211	237	272	263	267	285	274
Communist Europe [8]	165	174	185	189	186	183	184
World	150	157	166	166	166	166	167
PROCESSING INDUSTRIES							
Base metals:							
Non-Communist world	144	157	178	174	180	173	183
Industrialized countries [2]	142	155	175	173	178	171	180
United States and Canada	120	133	150	150	154	144	149
Europe	141	150	165	162	167	159	172
European Economic Community [3]	135	141	154	152	156	149	160
European Free Trade Association [4]	151	160	169	170	174	152	182
Australia and New Zealand	139	153	172	162	160	181	184
Less industrialized countries [5]	175	193	209	199	198	209	229
Latin America [6]	190	208	224	205	214	225	251
Asia [7]	152	171	191	196	177	190	200
Communist Europe [8]	173	183	194	196	194	194	191
World	153	165	182	181	184	179	185
Nonmetallic metal products:							
Non-Communist world	147	158	171	159	176	175	174
Industrialized countries [2]	142	152	165	152	171	168	167
United States and Canada	123	133	145	134	150	151	146

See footnotes at end of table.

Table 59.—United Nations' indexes of world[1] mineral industry production—Continued

(1963=100)

Industry sector and geographic area	1971	1972	1973	1973 by quarters: 1st	2nd	3d	4th
PROCESSING INDUSTRIES—Continued							
Nonmetallic mineral products—Continued							
Non-Communist world—Continued							
Industrialized countries—Continued							
Europe	152	160	170	157	178	172	176
European Economic Community [3]	145	153	161	149	161	163	163
European Free Trade Association [4]	157	165	173	163	179	169	181
Australia and New Zealand	143	150	163	147	159	172	175
Less industrialized countries [5]	188	203	223	200	224	230	229
Latin America [6]	195	210	233	225	228	238	239
Asia [7]	184	195	214	196	221	221	217
Communist Europe [8]	196	210	226	224	231	222	228
World	166	177	192	183	197	192	194
Chemicals, petroleum, and coal products:							
Non-Communist world	196	214	237	229	237	235	245
Industrialized countries [2]	196	214	237	230	239	235	245
United States and Canada	180	200	217	209	219	220	221
Europe	203	219	246	243	248	234	259
European Economic Community [3]	200	212	240	237	241	229	252
European Free Trade Association [4]	199	213	228	225	231	211	243
Australia and New Zealand	193	208	234	211	239	253	234
Less industrialized countries [5]	191	210	232	222	225	235	247
Latin America [6]	198	215	239	NA	NA	NA	NA
Asia [7]	188	210	229	226	216	227	246
Communist Europe [8]	240	265	301	298	305	301	300
World	205	224	250	243	251	248	256
OVERALL INDUSTRIAL PRODUCTION							
Non-Communist world	155	166	182	178	182	179	190
Industrialized countries [2]	152	163	179	175	179	175	186
United States and Canada	142	153	168	164	169	169	170
Europe	152	159	172	172	173	160	184
European Economic Community [3]	147	153	166	166	166	154	176
European Free Trade Association [4]	156	164	172	169	174	158	186
Australia and New Zealand	150	159	173	161	171	183	177
Less industrialized countries [5]	178	193	211	200	209	214	222
Latin America [6]	172	185	200	NA	NA	NA	NA
Asia [7]	178	196	219	213	212	222	229
Communist Europe [8]	191	206	225	227	227	221	224
World	165	177	194	191	195	191	199

NA Not available.
1 Excludes Albania, People's Republic of China, Mongolia, North Korea, and North Vietnam.
2 Canada, the United States, all countries of Europe except those listed in footnotes 1 and 8, the Republic of South Africa, Israel, Japan, Australia, and New Zealand.
3 Belgium, Denmark, France, West Germany, Ireland, Italy, Luxembourg, the Netherlands, and the United Kingdom.
4 Austria, Norway, Portugal, Sweden, and Switzerland.
5 Countries not indicated in footnotes 1, 2, and 8.
6 Corresponds to the United Nations classification "Caribbean, Central and South America."
7 Corresponds to the United Nations classification "Asia, excluding Israel and Japan."
8 Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Romania, and the U.S.S.R.
9 Reported as zero in source, but both Australia and New Zealand produce natural gas; insufficient data available to calculate index number.
Source: United Nations. Monthly Bulletin of Statistics, August 1974, pp. xii–xxv.

Table 60.—Comparisons of world and U.S. production and U.S. imports of principal minerals and mineral fuels in 1973

Mineral	World production (thousand short tons unless otherwise stated) p	U.S. production (percent of world production)	U.S. imports (percent of world production)	Total U.S. production and imports (percent of world production) 1973	Total U.S. production and imports (percent of world production) 1972 r
METALLIC ORES AND CONCENTRATES					
Bauxite -----thousand long tons--	69,910	2.7	16.1	18.8	20.7
Chromite ----------	7,507	--	25.7	25.7	15.1
Copper (content of ore and concentrate) ----------	7,857	21.9	1.9	23.8	24.9
Iron ore-------thousand long tons--	850,477	10.3	5.1	15.4	14.7
Lead (content of ore and concentrate) ----------	3,852	15.7	2.4	18.1	17.6
Mercury-thousand 76-pound flasks--	276,203	.8	16.7	17.4	13.0
Molybdenum (content of ore and concentrate) --thousand pounds--	181,152	64.0	--	64.0	64.0
Nickel (content of ore and concentrate) ----------	726	2.5	26.3	28.8	28.0
Platinum group (Pt, Pd, etc.) thousand troy ounces--	4,314	.5	54.2	54.7	43.4
Silver ----------do----	307,314	12.3	42.5	54.8	35.2
Titanium concentrates:					
Ilmenite [1] ----------	3,887	20.9	6.1	27.0	29.0
Rutile [1] ----------	368	--	65.5	65.5	62.0
Tungsten concentrate (60% tungsten dioxide) thousand pounds--	85,320	8.9	12.4	21.3	16.4
Zinc (content of ore and concentrate) ----------	6,377	7.5	2.4	9.9	10.5
METALS, SMELTER BASIS					
Aluminum ----------	13,349	33.9	4.6	38.5	40.6
Copper ----------	7,838	22.3	2.6	24.9	25.2
Iron, pig ----------	552,852	18.2	(2)	18.3	17.8
Lead ----------	3,801	18.1	4.8	22.9	25.0
Magnesium ----------	261	46.9	1.3	48.2	48.9
Steel ingots and castings ----------	766,000	19.7	2.0	21.7	21.8
Tin ----------thousand long tons--	227	2.2	20.3	22.5	23.7
Uranium oxide [1] -------short tons--	25,486	51.9	22.0	73.9	59.1
Zinc ----------	5,795	9.3	10.1	19.5	20.4
NONMETALS					
Asbestos ----------	4,598	3.3	17.2	20.5	21.2
Cement ----------	764,303	11.2	1.0	12.0	12.3
Diamond --------thousand carats--	43,489	--	56.0	56.0	47.1
Feldspar ----------	2,794	28.3	(2)	28.3	26.1
Fluorspar (marketable) ----------	4,962	5.0	24.4	29.4	27.9
Gypsum ----------	67,032	20.2	11.4	31.7	30.3
Mica (including scrap) ----------	289	61.2	2.1	63.3	75.0
Nitrogen, agricultural [3] ----------	42,202	30.5	2.3	32.8	35.1
Phosphate rock ----------	108,000	39.0	(2)	39.1	37.6
Potash (K_2O equivalent) ----------	24,212	10.8	14.8	25.6	25.0
Salt ----------	165,526	26.8	2.0	28.8	29.2
Sulfur, elemental thousand long tons--	31,555	34.6	3.9	38.5	40.7
MINERAL ENERGY RESOURCES					
Crude petroleum -thousand barrels--	20,357,175	16.5	5.8	22.3	23.0
Natural gas ---million cubic feet--	45,917,032	49.3	2.2	51.5	55.3
Bituminous coal and lignite ------	3,288,578	18.0	--	18.0	18.4
Anthracite ----------	191,919	3.6	--	3.6	3.7

p Preliminary. r Revised.
[1] World total exclusive of the U.S.S.R.
[2] Less than ½ unit.
[3] Year ended June 30, 1973.

Table 61.—Value of world export trade in major mineral commodity groups[1]

(Million U.S. dollars)

Commodity group [1]	1968	1969	1970	1971 r	1972
Metals:					
All ores, concentrates and scrap	5,590	6,340	8,010	7,200	7,670
Iron and steel	11,420	13,700	r 17,070	17,770	20,040
Nonferrous metals	9,440	10,870	r 12,210	10,350	11,550
Total metals	26,450	30,910	r 37,290	35,320	39,260
Nonmetals (crude only)	2,170	2,260	2,390	2,570	2,920
Mineral fuels	23,020	24,860	r 28,670	35,490	41,220
Grand total	51,640	58,030	r 68,350	73,380	83,400
All commodities	r 238,220	r 272,020	r 317,070	347,290	412,360

r Revised.

[1] Data presented are for selected major commodity groups of the Standard International Trade Classification—Revised (SITC—R) and as such exclude some mineral commodities classified in that data array together with other (nonmineral) commodities. SITC—R categories included are as follows: Ores, concentrates and scrap—SITC Division 28; iron and steel—SITC Division 67; nonferrous metals—SITC Division 68; nonmetals (crude only)—SITC Division 27; mineral fuels—SITC Division 3. Major items not included are the metals, metalloids, and metal oxides of SITC Group 513; mineral tar and crude chemicals from coal, petroleum, and natural gas of SITC Division 52; manufactured fertilizers of SITC Division 56; and nonmetallic mineral manufactures of SITC Groups 661, 662, 663, and 667.

Table 62.—Mineral commodity export price indexes

(1963=100)

Year and quarter	Metal ores	Fuels	All crude minerals
1971	126	127	127
1972	134	143	141
1973:			
First quarter	139	153	150
Second quarter	154	163	160
Third quarter	166	179	175
Fourth quarter	184	258	241
Annual average	161	188	181

Source: United Nations, Monthly Bureau of Statistics, New York, September 1974, p. xv.

Table 63.—Analysis of export price indexes

(1963=100)

Year and quarter	Developed areas		Developing areas	
	Total minerals	Nonferrous base metals	Total minerals	Nonferrous base metals
1971	145	151	119	161
1972	154	150	135	161
1973:				
First quarter	170	167	142	189
Second quarter	180	193	152	231
Third quarter	197	223	166	281
Fourth quarter	216	245	250	309
Annual average	191	207	178	252

Source: United Nations, Monthly Bureau of Statistics, New York, September 1974, p. xv.

Mining and Quarrying Trends in the Metal and Nonmetal Industries[1]

By John L. Morning[2]

Growing concern for environmental considerations, health and safety standards, price controls, inflation, material shortages, and increased dependence on imports created problems for the mineral industries in 1973. Although productivity increased for most mineral commodities, the annual rate of increase has slowed in recent years, indicating a maturing technological situation.[3]

Despite these problems, the mineral industry buoyed by strong demand in 1973 continued to expand and established new record highs for crude ore production and total material handled. Crude ore production rose 11% while total quantity of material handled increased 12% compared with that of 1972. Increased production of metallic crude ores outpaced that of nonmetals as metals increased 14% and nonmetals 10%. Along with the increase in quantity of crude ore produced, value of metallic and nonmetallic mineral output increased nearly 15% compared with that of 1972. Over the past decade, total value of metal and nonmetal crude ore output increased from $6,638 million in 1964 to $11,607 million in 1973.

Materials Handled.—Producers of metal and nonmetallic minerals (excluding fuels) handled nearly 4.7 billion tons of crude ore and waste, 12% more than in 1972 and 56% more than in 1964. Material handled at metal mines accounted for nearly 42% of the total material handled compared with 40% in 1972 and 31% in 1964.

Total tonnage of crude ore produced increased 11% and tonnage of waste material removed rose 13% compared with 1972 figures. Continuing a trend that was observed a decade ago, the percentage of crude ore to total material handled fell to 63% in 1973 compared with 66% in 1969 and 75% in 1964. Most of the growth in crude ore production and material handled in the mineral industry since 1960 (table 1) has been from the development of new surface mining operations and expansion of existing surface operations.

Fourteen States each reported handling over 100 million tons of material, an increase of three States over those reported in 1972. In 1964, only six States handled over 100 million tons of material. Three States reported handling over 200 million tons of crude ore while six other States each moved over 100 million tons of waste. The leading States in crude ore output were Florida (primarily phosphate rock and titanium minerals); Minnesota (primarily iron ore); and Arizona (primarily copper ore). The same three States were also leaders in waste material handled. Arizona reported moving 429 million tons of waste and accounted for 25% of the Nation's total. Arizona and Florida continued to lead the Nation in total material handled as they have since 1965.

Magnitude of the Mining Industry.—Output of crude ore in 1973 was reported from 14,437 mines and quarries, a 5% increase over the number of mines reporting in 1972. However, owing to an incomplete uranium canvass, many small uranium operations were not counted, and reporting uranium mines dropped to 75 from 189 for the previous year. In addition to the above mines, there were 109 wells, ponds, or pumping operations which produced sulfur, salt, lithium, boron, and magnesium. Output of crude ore from individual mines ranged from 1 to nearly 44 million tons

[1] Formerly Technologic Trends in the Mineral Industries.

[2] Supervisory physical scientist, Division of Ferrous Metals—Mineral Supply.

[3] Staff, Bureau of Mines. Technologic and Related Trends in the Mineral Industries, 1973. BuMines I.C. 8643, 1974, 52 pp.

and total material handled ranged from 1 to 138 million tons.

Twenty-one mines each reported over 10 million tons of crude ore production, five more mines than in 1972. Copper and phosphate rock accounted for the increase, as copper mines rose from 8 to 11 and phosphate rock mines from 2 to 4 mines. In 1966, 14 mines each had output of over 10 million tons of crude ore.

The 25 leading metal mines produced nearly 448 million tons of crude ore, 17% more than in 1973, and accounted for 68% of the total output of crude ore from metal mines. In terms of total material handled, the 25 leading metal mines moved 1,366 million tons of material, 19% more than in 1972.

The Minntac mine of United States Steel Corp. replaced the Utah Copper mine of Kennecott Copper Corp. as the leader in crude metal ore production. The Utah Copper mine had ranked first since 1968. Utah Copper, however, retained its leadership in total material handled for metal mines for the sixth successive year.

Various phosphate rock mines have been leaders in output of crude nonmetal ore during the past 10 years, but in 1973 the limestone producing Calcite mine of United States Steel Corp. ranked first in output of crude ore. The Kingsford mine of International Minerals and Chemical Corp. retained its leadership in total material handled.

The 25 leading nonmetal mines, in terms of crude ore output, produced 187 million tons of crude ore, 11% more than in 1972, and accounted for 8% of the total crude ore output from nonmetal mines. The 25 leading nonmetal mines, in terms of total material handled, moved 399 million tons of material, a decrease of 2%.

Copper mines (15) and iron mines (7) dominated the list for crude ore output at metal mines while phosphate rock mines (13) dominated the list for nonmetal mines. The same commodities topped the listings for total material handled. Arizona with 10 mines and Florida with 15 mines, had the most large mines in the top 25 metal and nonmetal mines, for output of crude ore.

Value of Principal Mineral Products.—When possible, the value measurement used in table 4 is for mine output, the form in which the minerals are extracted from the ground. For some commodities, the value is of beneficiated products. Values for some metals are assigned according to the average selling price of refined metal.

Average value for all commodities increased 4% compared with that of 1972. Compared with a decade earlier, average value rose 20%. For most mineral commodities, values continued to increase. Among the metals, only titanium (ilmenite) failed to increase significantly; for the nonmetals, diatomite, fluorspar, scrap mica, and dimension stone indicated decreased value per ton of ore mined.

Byproducts contributed to the value of nearly two-thirds of the mineral commodities listed in table 4. The value of byproducts was a significant part of the total value for the metals such as bauxite, 9%; copper, 8%; lead, 34%; silver, 19%; and zinc, 20%; and for the nonmetals such as feldspar, 9%; fluorspar, 9%; and salt, 15%. In general, values of products produced at underground mines were substantially higher than at surface mines. Byproducts accounted for 8% of the value for metal ores and 1% for nonmetal ores. Excluding the large volume commodities of sand and gravel and stone, byproducts contributed nearly 7% to the combined value of metal and nonmetal ores, and nearly 3% to nonmetal ores. Percentages for metal and nonmetal ore values were unchanged from those of 1972.

Comparison of Production From Surface and Underground Mines.—Crude ore production from surface mines continued to increase while that from underground mines remained relatively stable. Owing to the dominance of the large volume nonmetallic minerals—sand and gravel, stone, and clay—all of which are primarily mined by surface methods, little annual change was noted in the percentages of crude ore production from surface and underground operations. However, over the past decade surface crude ore production of copper increased from 84% to 89%; iron ore from 90% to nearly 96%; molybdenum from 0% to 29%; and talc, soapstone, and pyrophyllite from 43% to 64%. For all metal commodities, surface crude ore production increased from 81% in 1964 to 88% in 1973.

Three metal commodities, antimony, lead, and zinc, and three nonmetal commodities, potassium salts, sodium carbonate, and wollastonite were mined entirely by underground methods. Over 99% of the crude ore of tungsten was produced from underground operations. Crude ore production of 8 metals and 18 nonmetals came entirely from surface mines.

Ratio of Ore Treated to Marketable Product.—The ratio of ore treated to marketable product, the amount of ore processed to produce one unit of marketable product, varies with the type of mineral commodity. The ratio ultimately depends on the grade of ore treated and type of valuable mineral content. For many of the nonmetal commodities, the ratio is essentially one to one. Ratios are significantly lower for underground mines than for surface mines for a specific commodity because of higher mining costs.

Ratios for many of the mineral commodities increased in 1973 compared with those of 1972, continuing the trend that has persisted for more than a decade. Notable exceptions were lead and barite, both of which showed lower ratios.

Exploration and Development.—The reported 20.8 million feet in exploration and development work in 1973 continued the annual trend of reduced activity that has persisted in the minerals industry since 1969. All of the decreased activity compared with that of 1972 was for metals; nonmetal footage was about the same as in the previous year. Among the metals, only silver and tungsten indicated increased footage while copper footage decreased significantly. Although the overall total for nonmetallic minerals remained unchanged, footage for asbestos and gypsum decreased significantly and increased for all other nonmetals.

Exploration drilling including trenching decreased 17% compared with that of 1972. With the exception of churn drilling and other drilling methods, both of which indicated increased footage, other types of exploration methods showed reduced activity. In particular, percussion drilling was down 43% compared with that of 1972.

Underground development work was 19% lower than in 1972. Most of the decrease was in drifting and crosscutting, primarily for metals.

Four States, two less than in 1972, reported over 1 million feet of exploration and development work. Wyoming led the nation with 25% of the total, followed by South Dakota, 20%; New Mexico, 18%; and Texas, 15%. Exploration and development activity in Wyoming was primarily for uranium; in South Dakota, for gold and uranium; in New Mexico, for copper and uranium; and in Texas, for iron-ore and uranium.

Data presented in table 16 on total material handled from development work is not directly comparable with that of previous years because of a change in statistical reporting. Stripping data includes only that related to development work in preparing a proved ore body for mining. Stripped material from producing operations is included in table 2.

Explosives.—Total consumption of explosives in the United States in 1973 continued to increase and set a new record high for the fifth consecutive year. The average growth rate for the past 5 years has been 4.4% annually. Of the total industrial consumption, the minerals industry accounted for 84%. Although explosive usage decreased in coal mining, this loss was more than offset by increased consumption in metal and nonmetal mining including quarrying. The increase in consumption was due to continued growth in the use of blasting agents.

Of the 2.3 billion pounds of explosives used in the minerals industry, coal mining accounted for 51%, metal mining 21%, and quarrying and nonmetal mining 28%. Kentucky, Pennsylvania, and Alabama were the leading States in explosive consumption for coal mining, accounting for 52% of the total. Arizona, Minnesota, and New Mexico were leading States in explosive consumption for metal mining, accounting for 65% of the total. For nonmetal mining and quarrying, Kentucky, Ohio, and Pennsylvania were leading States accounting for 20% of total explosives used in this category.

Blasting agents and unprocessed ammonium nitrate were the leading explosives used, accounting for 70% of the total explosives used in the minerals industry.

Beginning in 1972, the Institute of Makers of Explosives (IME) adopted new product classifications for industrial explosives and blasting agents. As a result, detailed data are not directly comparable with previous years.

More detailed explosives information is published in the Annual Explosive issue, Mineral Industry Surveys, prepared by the Division of Nonmetallic Minerals, Bureau of Mines.

Table 1.—Material handled at surface and underground mines in the United States, by type

(Million short tons)

Type and year	Surface			Underground			All mines [1]		
	Crude ore	Waste	Total [1]	Crude ore	Waste	Total [1]	Crude ore	Waste	Total
Metals:									
1960	336	508	844	86	8	94	421	516	938
1961	340	415	755	83	7	91	423	422	846
1962	346	434	780	76	7	83	422	441	863
1963	354	463	817	76	7	83	430	470	900
1964	376	455	830	83	7	90	458	462	920
1965	390	505	895	87	6	94	477	511	989
1966	412	634	1,050	88	7	95	500	641	1,140
1967	353	619	972	74	7	81	427	626	1,050
1968	402	717	1,120	79	13	92	481	730	1,210
1969	455	941	1,400	85	13	98	540	954	1,490
1970	499	968	1,470	87	7	94	586	975	1,560
1971	480	1,020	1,500	80	6	86	560	1,020	1,580
1972	491	1,080	1,570	86	5	91	576	1,080	1,660
1973	574	1,280	1,860	82	9	91	655	1,290	1,950
Nonmetals:									
1960	1,550	236	1,790	57	1	58	1,610	236	1,850
1961	1,590	188	1,780	65	1	66	1,660	190	1,850
1962	1,590	224	1,810	62	1	63	1,650	225	1,880
1963	1,640	261	1,900	67	2	69	1,710	263	1,970
1964	1,740	277	2,010	69	2	71	1,800	279	2,080
1965	1,850	296	2,140	78	3	81	1,930	299	2,220
1966	1,930	368	2,300	77	2	79	2,010	370	2,380
1967	1,910	399	2,310	78	3	81	1,990	402	2,390
1968	1,870	413	2,280	78	3	81	1,950	416	2,360
1969	2,000	375	2,380	80	2	82	2,080	377	2,460
1970	2,010	431	2,440	80	4	84	2,090	435	2,530
1971	1,980	442	2,420	73	5	78	2,050	447	2,500
1972	2,020	415	2,430	77	5	82	2,100	420	2,520
1973	2,240	418	2,650	82	1	83	2,320	419	2,740
Total metals and nonmetals: [1]									
1960	1,890	744	2,630	143	9	152	2,030	753	2,780
1961	1,930	603	2,540	148	9	156	2,080	612	2,690
1962	1,940	658	2,590	138	8	146	2,070	666	2,740
1963	1,990	724	2,720	142	9	152	2,140	734	2,870
1964	2,110	731	2,840	152	9	161	2,260	740	3,000
1965	2,240	801	3,040	165	9	175	2,400	810	3,210
1966	2,340	1,000	3,340	165	9	174	2,510	1,010	3,520
1967	2,260	1,020	3,280	152	10	162	2,410	1,030	3,440
1968	2,270	1,130	3,400	157	16	173	2,430	1,150	3,580
1969	2,460	1,320	3,770	165	15	180	2,620	1,330	3,950
1970	2,510	1,400	3,910	167	11	178	2,680	1,410	4,090
1971	2,460	1,460	3,920	153	11	164	2,610	1,470	4,080
1972	2,500	1,500	4,000	163	10	173	2,670	1,510	4,180
1973	2,810	1,700	4,510	163	11	174	2,970	1,710	4,680

[1] Data may not add to totals shown because of independent rounding.

Table 2.—Material handled at surface and underground mines, by commodity,[1] in 1973

(Thousand short tons)

Commodity	Surface			Underground			All mines [2]		
	Crude ore	Waste	Total [2]	Crude ore	Waste	Total [2]	Crude ore	Waste	Total
METALS									
Bauxite	[3] 2,780	12,400	[3] 15,200	W	--	W	2,780	12,400	15,200
Copper	286,000	757,000	1,040,000	34,900	1,270	36,100	320,000	758,000	1,080,000
Gold:									
Lode	2,590	8,760	11,300	1,650	208	1,860	4,240	8,960	13,200
Placer	1,500	[3] 468	[3] 1,970	--	W	W	1,500	468	1,970
Iron ore	233,000	255,000	488,000	10,800	1,830	12,700	244,000	257,000	501,000
Lead	([4])	4	4	9,300	1,880	11,200	9,300	1,880	11,200
Mercury	16	402	418	14	2	16	30	404	434
Silver	29	37	66	620	444	1,060	649	482	1,130
Titanium: Ilmenite	32,300	7,450	39,800	--	--	--	32,300	7,450	39,800
Tungsten	4	650	654	744	158	902	748	808	1,560
Uranium	4,190	201,000	205,000	1,780	1,030	2,820	5,970	202,000	208,000
Zinc	--	13	13	6,730	1,710	8,440	6,730	1,720	8,450
Other [5]	11,500	38,500	50,000	15,000	820	15,800	26,500	39,300	65,800
Total metals [2]	574,000	1,280,000	1,860,000	81,600	9,360	91,000	655,000	1,290,000	1,950,000
NONMETALS									
Abrasives [6]	60	123	183	68	--	68	128	123	251
Asbestos	[3] 2,700	2,260	[3] 4,960	W	--	W	2,700	2,260	4,960
Barite	4,360	3,760	8,120	162	28	190	4,520	3,790	8,310
Clays	57,900	e 50,300	108,000	817	e 12	829	58,700	50,300	109,000
Diatomite	698	4,290	4,990	--	--	--	698	4,290	4,990
Feldspar	[3] 1,900	[3] 573	[3] 2,470	W	W	W	1,900	573	2,470
Fluorspar	98	11	108	607	76	683	705	87	791
Gypsum	11,300	14,300	25,500	2,740	108	2,850	14,000	14,400	28,400
Mica (scrap)	1,790	2,160	3,950	--	--	--	1,790	2,160	3,950
Perlite	[3] 759	115	[3] 874	W	--	W	759	115	874
Phosphate rock	138,000	234,000	372,000	226	29	255	138,000	234,000	372,000
Potassium salts	--	--	--	17,100	275	17,400	17,100	275	17,400
Pumice	3,820	475	4,290	--	--	--	3,820	475	4,290
Salt	472	71	543	12,500	415	12,900	12,900	486	13,400
Sand and gravel	984,000	--	984,000	--	--	--	984,000	--	984,000
Sodium carbonate (natural)	--	--	--	6,420	121	6,540	6,420	121	6,540
Stone:									
Crushed and broken	1,010,000	e 83,400	1,100,000	40,500	e 326	40,800	1,050,000	83,700	1,140,000
Dimension	e 2,670	e 1,410	4,080	2	--	2	2,670	1,410	4,080
Talc, soapstone, and pyrophyllite	837	2,090	2,930	481	79	560	1,320	2,170	3,490
Other [7]	10,400	18,600	29,000	128	--	128	10,500	18,600	29,100
Total nonmetals [2]	2,240,000	418,000	2,650,000	81,700	1,470	83,200	2,320,000	419,000	2,740,000
Grand total [2]	2,810,000	1,700,000	4,510,000	163,000	10,800	174,000	2,970,000	1,710,000	4,680,000

e Estimate. W Withheld to avoid disclosing individual company confidential data, included with "Surface."

[1] Excludes material from wells, ponds, or pumping stations.

[2] Data may not add to totals shown because of independent rounding.

[3] Includes underground; the Bureau of Mines is not at liberty to publish separately.

[4] Less than ½ unit.

[5] Antimony, beryllium, manganiferrous ore, molybdenum, nickel, platinum-group metals, rare-earth metals, tin, and vanadium.

[6] Emery, garnet, and tripoli.

[7] Abrasive stone, aplite, boron minerals, graphite, greensand marl, iron oxide pigments (crude), kyanite, lithium minerals, magnesite, mica (sheet), millstones, olivine, vermiculite, and wollastonite.

Table 3.—Material handled at surface and underground mines, by State, in 1973 [1] (including sand and gravel and stone)

(Thousand short tons)

State	Surface			Underground			All mines [2]		
	Crude ore	Waste	Total [2]	Crude ore	Waste	Total [2]	Crude ore	Waste	Total
Alabama	32,400	6,000	38,400	W	--	W	32,400	6,000	38,400
Alaska	24,500	535	25,100	--	W	W	24,500	535	25,100
Arizona	196,000	428,000	624,000	23,300	1,130	24,400	219,000	429,000	649,000
Arkansas	33,000	12,400	45,400	845	27	872	33,800	12,400	46,200
California	183,000	66,400	249,000	1,720	187	1,900	184,000	66,600	251,000
Colorado	41,500	5,630	47,100	16,900	1,600	18,500	58,400	7,230	65,600
Connecticut	17,800	18	17,800	--	--	--	17,800	18	17,800
Delaware	3,420	--	3,420	--	--	--	3,420	--	3,420
Florida	230,000	183,000	413,000	--	--	--	230,000	183,000	413,000
Georgia	57,000	1,860	58,800	1,110	--	1,110	58,100	1,860	59,900
Hawaii	8,260	--	8,260	--	--	--	8,260	--	8,260
Idaho	16,500	20,600	37,000	1,690	725	2,420	18,100	21,300	39,500
Illinois	108,000	--	108,000	3,690	54	3,740	112,000	54	112,000
Indiana	61,000	--	61,000	1,090	7	1,100	62,100	7	62,100
Iowa	51,400	2,470	53,800	2,140	--	2,140	53,500	2,470	56,000
Kansas	29,800	--	29,800	3,810	37	3,840	33,600	37	33,600
Kentucky	41,500	--	41,500	8,120	1	8,120	49,600	1	49,600
Louisiana	26,000	--	26,000	5,450	49	5,500	31,400	49	31,500
Maine	14,800	--	14,800	W	W	W	14,800	--	14,800
Maryland	32,200	--	32,200	W	--	W	32,200	--	32,200
Massachusetts	27,500	--	27,500	--	--	--	27,500	--	27,500
Michigan	139,000	34,100	173,000	12,700	110	12,800	151,000	34,200	185,000
Minnesota	220,000	157,000	377,000	--	--	--	220,000	157,000	377,000
Mississippi	17,400	--	17,400	--	--	--	17,400	--	17,400
Missouri	56,800	2,610	59,400	22,000	2,350	24,300	78,800	5,000	83,800
Montana	39,800	72,700	113,000	861	112	973	40,700	72,800	114,000
Nebraska	20,400	--	20,400	1,080	--	1,080	21,400	--	21,400
Nevada	43,500	60,800	104,000	43	88	131	43,500	60,900	104,000
New Hampshire	9,670	--	9,670	--	--	--	9,670	--	9,670
New Jersey	40,000	137	40,200	W	--	W	40,000	137	40,200
New Mexico	65,200	153,000	218,000	19,000	979	20,000	84,200	154,000	238,000
New York	81,000	3,070	84,000	5,160	155	5,310	86,100	3,230	89,400
North Carolina	64,500	16,600	81,100	--	--	--	64,500	16,600	81,100
North Dakota	6,070	--	6,070	--	--	--	6,070	--	6,070
Ohio	108,000	--	108,000	3,670	276	3,950	111,000	276	112,000
Oklahoma	36,100	9,700	45,800	W	--	W	36,100	9,700	45,800
Oregon	39,800	689	40,500	1	5	6	39,800	694	40,500
Pennsylvania	98,900	79	98,900	6,460	832	7,300	105,000	911	106,000
Rhode Island	2,900	--	2,900	--	--	--	2,900	--	2,900
South Carolina	25,700	--	25,700	--	--	--	25,700	--	25,700
South Dakota	17,200	96	17,300	W	W	W	17,200	96	17,300
Tennessee	58,600	8,800	67,400	5,650	182	5,840	64,200	8,980	73,200
Texas	112,000	37,400	149,000	274	--	274	112,000	37,400	149,000
Utah	63,000	113,000	175,000	512	281	793	63,500	113,000	176,000
Vermont	6,870	190	7,060	217	9	226	7,080	199	7,280
Virginia	59,300	126	59,400	1,850	673	2,530	61,200	799	62,000

Washington	39,700	381	40,100	279	135	414	40,000	516	40,500
West Virginia	15,800	--	15,800	2,380	--	2,380	18,200	--	18,200
Wisconsin	66,700	5,090	71,800	481	--	481	67,200	5,090	72,300
Wyoming	19,300	162,000	182,000	7,350	138	7,490	26,600	163,000	189,000
Undistributed [3]	2,670	135,000	138,000	3,560	683	4,240	6,230	136,000	142,000
Total [2]	2,810,000	1,700,000	4,510,000	163,000	10,800	174,000	2,970,000	1,710,000	4,680,000

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Excludes material from wells, ponds or pumping operations.
[2] Data may not add to totals shown because of independent rounding.
[3] Includes estimated data in table 2.

Table 4.—Value of principal mineral products and byproducts of surface and underground ores mined in the United States, in 1973

(Value per ton)

Ore	Surface			Underground			All mines		
	Principal mineral product	By-product	Total	Principal mineral product	By-product	Total	Principal mineral product	By-product	Total
METALS									
Bauxite	[1] $9.59	$0.93	[1] $10.52	W	--	W	$9.59	$0.93	$10.52
Copper	6.36	.59	6.95	$9.83	$0.87	$10.70	6.77	.62	7.39
Gold:									
Lode	7.39	.19	7.58	23.09	.43	23.52	13.02	.28	13.30
Placer	.78	.01	.79	--	--	--	.78	.01	.79
Iron ore	4.58	.01	4.59	8.63	.04	8.67	4.77	.01	4.78
Lead	112.75	86.45	199.20	20.50	10.64	31.14	20.50	10.64	31.14
Mercury	9.75	--	9.75	32.44	--	32.44	20.44	--	20.44
Silver	9.11	2.27	11.38	43.31	10.13	53.44	41.87	9.80	51.67
Titanium: Ilmenite	.61	.25	.86	--	--	--	.61	.25	.86
Tungsten	2.34	--	2.34	21.02	3.11	24.13	19.41	2.84	22.25
Uranium	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	W	W	W	[2] 20.26	[2] 4.96	[2] 25.22	20.26	4.96	25.22
Average value [3]	5.19	.30	5.49	11.63	2.09	13.72	6.02	.54	6.56
NONMETALS									
Asbestos	[1] 6.00	.02	[1] 6.02	W	--	W	6.00	.02	6.02
Barite	3.63	.06	3.69	23.88	--	23.88	4.49	.06	4.55
Clays	5.80	--	5.80	9.01	--	9.01	5.85	--	5.85
Diatomite	59.26	--	59.26	--	--	--	59.26	--	59.26
Feldspar	6.52	.67	7.19	3.37	--	3.37	6.50	.66	7.16
Fluorspar	11.30	--	11.30	26.02	2.64	28.66	23.71	2.22	25.93
Gypsum	3.66	.08	3.74	5.65	--	5.65	4.05	.06	4.11
Mica (scrap)	12.80	--	12.80	--	--	--	12.80	--	12.80
Perlite	[1] 9.28	--	[1] 9.28	W	--	W	9.28	--	9.28
Phosphate rock	1.71	.05	1.76	11.17	--	11.17	1.73	.05	1.78
Potassium salts	--	--	--	5.38	.09	5.47	5.38	.09	5.47
Pumice	2.33	--	2.33	--	--	--	2.33	--	2.33
Salt	2.13	.57	2.70	6.26	1.12	7.38	6.11	1.10	7.21
Sand and gravel	1.38	--	1.38	--	--	--	1.38	--	1.38
Sodium carbonate (natural)	--	--	--	13.18	--	13.18	13.18	--	13.18
Stone:									
Crushed and broken	1.79	.01	1.80	2.23	.01	2.24	1.81	.01	1.82
Dimension	54.12	--	54.12	390.69	--	390.69	54.66	--	54.66
Talc, soapstone, pyrophyllite	6.69	--	6.69	7.57	--	7.57	7.01	--	7.01
Vermiculite	2.03	--	2.03	--	--	--	2.03	--	2.03
Average value [3]	1.83	.01	1.84	4.87	.21	5.08	1.94	.02	1.96

Average value—metals and nonmetals [3]	2.49	.07	2.56	8.54	1.19	9.73	2.81	.13	2.94
Average value—nonmetals (excluding stone, and sand and gravel) [3]	3.63	.05	3.68	7.45	.41	7.86	4.20	.11	4.31
Average value—metals and nonmetals (excluding stone, and sand and gravel) [3]	4.72	.23	4.95	10.24	1.53	11.77	5.47	.41	5.88

NA Not available. W Withheld to avoid disclosing individual company confidential data; included with "Surface or Underground."
[1] Includes underground; the Bureau of Mines is not at liberty to publish separately.
[2] Includes surface; the Bureau of Mines is not at liberty to publish separately.
[3] Includes unpublished data.

Table 5.—Crude ore and total material handled at surface and underground mines, by commodity, in 1973

(Percent)

Commodity	Crude ore		Total material	
	Surface	Underground	Surface	Underground
METALS				
Antimony	--	100.0	--	100.0
Bauxite	[1] 100.0	W	[1] 100.0	W
Beryllium	100.0	--	100.0	--
Copper	89.1	10.9	96.7	3.3
Gold:				
Lode	61.1	38.9	85.9	14.1
Placer	100.0	--	99.7	.3
Iron ore	95.6	4.4	97.5	2.5
Lead	--	100.0	--	100.0
Mercury	52.8	47.2	96.2	3.8
Molybdenum	29.1	70.9	73.2	26.8
Nickel	100.0	--	100.0	--
Platinum-group metals	100.0	--	100.0	--
Rare-earth metals	100.0	--	100.0	--
Silver	4.4	95.6	5.8	94.2
Tin	100.0	--	100.0	--
Titanium	100.0	--	100.0	--
Tungsten	.6	99.4	42.0	58.0
Uranium	70.1	29.9	98.6	1.4
Vanadium	100.0	--	100.0	--
Zinc	--	100.0	.2	99.8
Total metals	87.5	12.5	95.3	4.7
NONMETALS				
Abrasives:				
Emery	100.0	--	100.0	--
Garnet	100.0	--	100.0	--
Tripoli	33.1	66.9	33.1	66.9
Abrasive stone	100.0	--	100.0	--
Aplite	100.0	--	100.0	--
Asbestos	99.4	.6	99.7	.3
Barite	96.4	3.6	97.7	2.3
Boron minerals	100.0	--	100.0	--
Clays	98.6	1.4	98.6	1.4
Diatomite	100.0	--	100.0	--
Feldspar	99.1	.9	99.3	.7
Fluorspar	13.9	86.1	13.7	86.3
Graphite	100.0	--	100.0	--
Greensand marl	100.0	--	100.0	--
Gypsum	80.3	19.7	89.9	10.1
Iron oxide pigments (crude)	41.8	58.2	70.6	29.4
Kyanite	100.0	--	100.0	--
Lithium minerals	100.0	--	100.0	--
Magnesite	100.0	--	100.0	--
Mica (scrap)	100.0	--	100.0	--
Mica (sheet)	100.0	--	100.0	--
Millstone	100.0	--	100.0	--
Olivine	100.0	--	100.0	--
Perlite	99.4	.6	99.5	.5
Phosphate rock	99.8	.2	99.9	.1
Potassium salts	--	100.0	--	100.0
Pumice	100.0	--	100.0	--
Salt	3.6	96.4	4.0	96.0
Sand and gravel	100.0	--	100.0	--
Sodium carbonate (natural)	--	100.0	--	100.0
Stone:				
Crushed and broken	96.2	3.8	96.2	3.8
Dimension	99.8	.2	99.8	.2
Talc, soapstone, pyrophyllite	63.5	36.5	83.9	16.1
Vermiculite	100.0	--	100.0	--
Wollastonite	--	100.0	--	100.0
Total nonmetals	96.5	3.5	96.8	3.2
Grand total	94.5	5.5	96.2	3.8

W Withheld to avoid disclosing individual company confidential data; included with "Surface."
[1] Includes underground; the Bureau of Mines is not at liberty to publish separately.

Table 6.—Crude ore and total material handled at surface and underground mines, by State, in 1973

(Percent)

State	Crude ore		Total material	
	Surface	Underground	Surface	Underground
Alabama	98	2	98	2
Alaska	100	--	100	--
Arizona	89	11	96	4
Arkansas	97	3	98	2
California	99	1	99	1
Colorado	71	29	72	28
Connecticut	100	--	100	--
Delaware	100	--	100	--
Florida	100	--	100	--
Georgia	98	2	98	2
Hawaii	100	--	100	--
Idaho	91	9	94	6
Illinois	97	3	97	3
Indiana	98	2	98	2
Iowa	96	4	96	4
Kansas	89	11	89	11
Kentucky	84	16	84	16
Louisiana	83	17	83	17
Maine	99	1	98	2
Maryland	99	1	99	1
Massachusetts	100	--	100	--
Michigan	92	8	93	7
Minnesota	100	--	100	--
Mississippi	100	--	100	--
Missouri	72	28	71	29
Montana	98	2	99	1
Nebraska	95	5	95	5
Nevada	100	--	100	--
New Hampshire	100	--	100	--
New Jersey	99	1	99	1
New Mexico	77	23	92	8
New York	94	6	94	6
North Carolina	100	--	100	--
North Dakota	100	--	100	--
Ohio	97	3	96	4
Oklahoma	98	2	98	2
Oregon	100	--	100	--
Pennsylvania	94	6	93	7
Rhode Island	100	--	100	--
South Carolina	100	--	100	--
South Dakota	92	8	91	9
Tennessee	91	9	92	8
Texas	100	--	100	--
Utah	99	1	99	1
Vermont	97	3	97	3
Virginia	97	3	96	4
Washington	99	1	99	1
West Virginia	87	13	87	13
Wisconsin	99	1	99	1
Wyoming	72	28	96	4
Total	94	6	96	4

Table 7.—Number of domestic metal and nonmetal mines in 1973, by commodity and magnitude of crude ore production [1]

Commodity	Total number of mines	Less than 1,000 tons	1,000 to 10,000 tons	10,000 to 100,000 tons	100,000 to 1,000,000 tons	1,000,000 to 10,000,000 tons	More than 10,000,000 tons
METALS							
Bauxite	16	--	3	8	5	--	--
Copper	64	14	3	4	15	17	11
Gold:							
Lode	29	19	5	1	2	2	--
Placer	50	29	10	9	2	--	--
Iron ore	69	--	9	9	22	25	4
Lead	36	19	1	2	11	3	--
Mercury	21	13	8	--	--	--	--
Silver	41	20	11	8	2	--	--
Titanium: Ilmenite	7	--	--	--	--	7	--
Tungsten	25	22	1	1	1	--	--
Uranium [2]	75	18	15	25	16	1	--
Zinc	28	2	2	4	20	--	--
Other [3]	12	--	2	3	2	4	1
Total metals	473	156	70	74	98	59	16
NONMETALS							
Abrasives [4]	9	--	5	4	--	--	--
Asbestos	6	--	1	1	2	2	--
Barite	41	1	8	16	16	--	--
Boron minerals	2	--	--	1	--	1	--
Clays	1,420	112	406	750	152	--	--
Diatomite	13	1	5	5	2	--	--
Feldspar	21	1	2	10	8	--	--
Fluorspar	16	1	10	2	3	--	--
Gypsum	75	--	3	30	42	--	--
Mica (scrap)	15	1	3	4	7	--	--
Perlite	12	1	4	5	2	--	--
Phosphate rock	42	1	6	--	13	18	4
Potassium salts	7	--	--	--	1	6	--
Pumice	158	9	52	91	6	--	--
Salt	18	--	2	1	9	6	--
Sand and gravel	6,995	140	1,014	3,483	2,240	118	--
Sodium carbonate (natural)	3	--	--	--	--	3	--
Stone:							
Crushed and broken	4,623	231	699	1,770	1,717	205	1
Dimension	405	207	170	28	--	--	--
Talc, soapstone, pyrophyllite	51	6	22	20	3	--	--
Vermiculite	3	--	1	--	1	1	--
Other [5]	29	10	7	3	9	--	--
Total nonmetals	13,964	722	2,420	6,224	4,233	360	5
Grand total	14,437	878	2,490	6,298	4,331	419	21

[1] Excludes wells, ponds, or pumping operations.
[2] Data incomplete.
[3] Antimony, beryllium, manganiferrous ore, molybdenum, nickel, platinum-group metals, rare-earth metals, tin, and vanadium.
[4] Emery, garnet, and tripoli.
[5] Abrasive stone, aplite, graphite, greensand marl, iron oxide pigments (crude), kyanite, lithium minerals, magnesite, mica (sheet), millstones, olivine, and wollastonite.

Table 8.—Twenty-five leading metal and nonmetal[1] mines in the United States in 1973, in order of output of crude ore

Mine	State	Operator	Commodity	Mining method
		METALS		
Minntac	Minn	United States Steel Corp	Iron ore	Open pit.
Utah Copper	Utah	Kennecott Copper Corp	Copper	Do.
Erie Commercial (Hoyt Lake).	Minn	Pickands Mather & Co	Iron ore	Do.
Tyrone	N. Mex	Phelps Dodge Corp	Copper	Do.
Peter Mitchell	Minn	Reserve Mining Co	Iron ore	Do.
Sierrita	Ariz	Duval Sierrita Corp	Copper	Do.
San Manuel	do	Magma Copper Co	do	Caving.
Pima	do	Pima Mining Co	do	Open pit.
Morenci	do	Phelps Dodge Corp	do	Do.
Berkeley Pit	Mont	The Anaconda Company	do	Do.
Twin Buttes	Ariz	Anamax Mining Co	do	Do.
Climax	Colo	American Metal Climax, Inc.	Molybdenum	Caving.
Yerington	Nev	The Anaconda Company	Copper	Open pit.
Empire	Mich	Cleveland-Cliffs Iron Co	Iron ore	Do.
Eagle Mountain	Calif	Kaiser Steel Corp	do	Do.
Ray Pit	Ariz	Kennecott Copper Corp	Copper	Do.
New Cornelia	do	Phelps Dodge Corp	do	Do.
Butler Project	Minn	The Hanna Mining Co	Iron ore	Do.
Republic	Mich	Cleveland-Cliffs Iron Co	do	Do.
White Pine	do	White Pine Copper Co	Copper	Open stopes.
Mission	Ariz	American Smelting & Refining Co.	do	Open pit.
Inspiration	do	Inspiration Consolidated Copper Co.	do	Do.
Highland	Fla	E. I. duPont de Nemours & Co.	Ilmenite	Dredging.
Trail Ridge	do	do	do	Do.
Mineral Park	Ariz	Duval Corp	Copper	Open pit.
		NONMETALS		
Calcite	Mich	United States Steel Corp	Stone	Open quarry.
Suwannee	Fla	Occidental Petroleum Corp	Phosphate rock	Open pit.
Kingsford	do	International Minerals & Chemical Corp.	do	Do.
Ft. Meade	do	Mobil Oil Corp	do	Do.
Haynsworth	do	American Cyanamid Co	do	Do.
Payne Creek	do	Continental Oil Co	do	Do.
Noralyn	do	International Minerals & Chemical Corp.	do	Do.
Rockland	do	United States Steel Corp	do	Do.
Palmetto	do	Continental Oil Co	do	Do.
Thornton	Ill	General Dynamics Corp	Stone	Open quarry.
Stoneport	Mich	Presque Isle Corp	do	Do.
Clear Spring	Fla	International Minerals & Chemical Corp.	Phosphate rock	Open pit.
Nichols	do	Mobil Oil Corp	do	Do.
Bonny Lake	do	W. R. Grace & Co	do	Do.
Feld	Tex	Texas Crushed Stone Co	Stone	Open quarry.
Pennsuco	Fla	Maule Industries, Inc	do	Do.
McCook 378	Ill	Vulcan Materials Co	do	Do.
Silver City	Fla	Swift Agricultural Chemical Corp.	Phosphate rock	Open pit.
Clinton	N. Y	Lone Star Industries, Inc	Stone	Open quarry.
Pt. Charlot	Fla	General Development Corp	Sand and gravel	Open pit.
International	N. Mex	International Minerals & Chemical Corp.	Potassium salts	Open stopes.
Zonolite	Mont	W. R. Grace & Co	Vermiculite	Open pit.
Saddle Creek	Fla	Continental Oil Co	Phosphate rock	Do.
Hi Calcium	Mich	Inland Steel Co	Stone	Open quarry.
Beckman	Tex	McDonough Bros., Inc	do	Do.

[1] Brines and materials from wells excepted.

Table 9.—Twenty-five leading metal and nonmetal[1] mines in the United States in 1973, in order of output of total materials handled

Mine	State	Operator	Commodity	Mining method
		METALS		
Utah Copper	Utah	Kennecott Copper Corp	Copper	Open pit.
Twin Buttes	Ariz	Anamax Mining Co	do	Do.
Tyrone	N. Mex	Phelps Dodge Corp	do	Do.
Minntac	Minn	United States Steel Corp	Iron ore	Do.
Berkeley Pit	Mont	The Anaconda Company	Copper	Do.
Erie Commercial (Hoyt Lake).	Minn	Pickands Mather & Co	Iron ore	Do.
Sierrita	Ariz	Duval Sierrita Corp	Copper	Do.
Eagle Mountain	Calif	Kaiser Steel Corp	Iron ore	Do.
Morenci	Ariz	Phelps Dodge Corp	Copper	Do.
Lucky Mc	Wyo	Utah International, Inc	Uranium	Artificial stopes.
Pima	Ariz	Pima Mining Co	Copper	Open pit.
Mitchell Pit	Minn	Reserve Mining Co	Iron ore	Do.
Ruth	Nev	Kennecott Copper Corp	Copper	Do.
Ray Pit	Ariz	do	do	Do.
Questa	N. Mex	Molybdenum Corp. of America.	Molybdenum	Do.
Shirley Basin	Wyo	Utah International, Inc	Uranium	Do.
Pinto Valley	Ariz	Cities Service Co	Copper	Do.
Mission	do	American Smelting & Refining Co.	do	Do.
Chino	N. Mex	Kennecott Copper Corp	do	Do.
New Cornelia	Ariz	Phelps Dodge Corp	do	Do.
Yerington	Nev	The Anaconda Company	do	Do.
Inspiration	Ariz	Inspiration Consolidated Copper Corp.	do	Do.
Highland	Wyo	Exxon Corp	Uranium	Do.
San Manuel	Ariz	Magma Copper Co	Copper	Caving.
Empire	Mich	Cleveland-Cliffs Iron Co	Iron ore	Open pit.
		NONMETALS		
Kingsford	Fla	International Minerals & Chemical Corp.	Phosphate rock	Open pit.
Suwannee	do	Occidential Petroleum Corp.	do	Do.
Haynsworth	do	American Cyanamid Co	do	Do.
Bonny Lake	do	W. R. Grace & Co	do	Do.
Noralyn	do	International Minerals & Chemical Corp.	do	Do.
Rockland	do	United States Steel Corp	do	Do.
Ft. Meade	do	Mobil Oil Corp	do	Do.
Clear Spring	do	International Minerals & Chemical Corp.	do	Do.
Lee Creek	N. Car	Texasgulf, Inc	do	Do.
Nichols	Fla	Mobil Oil Corp	do	Do.
Calcite	Mich	United States Steel Corp	Stone	Open quarry.
Boron	Calif	U.S. Borax & Chemical Corp.	Boron	Open pit.
Watson	Fla	Swift Agricultural Chemicals Corp.	Phosphate rock	Do.
Silver City	do	do	do	Do.
Gay	Idaho	J. R. Simplot Co	do	Do.
Tampa Agricultural Chemical Operations.	Fla	Gardinier, Inc	do	Do.
Payne Creek	do	Continental Oil Co	do	Do.
Palmetto	do	do	do	Do.
Thornton	Ill	General Dynamics Corp	Stone	Open quarry.
Stoneport	Mich	Presque Isle Corp	do	Do.
Zonolite	Mont	W. R. Grace & Co	Vermiculite	Open pit.
Crawford	Utah	Stauffer Chemical Co	Phosphate rock	Do.
Vernal	do	do	do	Do.
Feld	Tex	Texas Crushed Stone Co	Stone	Open quarry.
Pennsuco	Fla	Maule Industries, Inc	do	Do.

[1] Brines and materials from wells excepted.

Table 10.—Ore treated or sold per unit of marketable product at surface and underground mines in the United States, by commodity, in 1973

Commodity	Unit of marketable product	Surface			Underground			Total [1]		
		Ore treated (thousand short tons)	Marketable product (units)	Ratio of units of ore to units of marketable product	Ore treated (thousand short tons)	Marketable product (units)	Ratio of units of ore to units of marketable product	Ore treated (thousand short tons)	Marketable product (units)	Ratio of units of ore to units of marketable product
METALS										
Bauxite	thousand long tons	[2] 2,780	[2] 1,880	[2] 1.5:1	W	W	W	2,780	1,880	1.5:1
Copper	thousand short tons	263,000	1,410	187.0:1	34,900	288	121.0:1	298,000	1,690	175.8:1
Gold:										
Lode	thousand troy ounces	2,940	222	13.2:1	1,640	387	4.2:1	4,580	609	7.5:1
Placer	do	1,500	12	125.3:1	--	--	--	1,500	12	125.3:1
Iron ore	thousand long tons	232,000	83,500	2.8:1	11,400	7,070	1.6:1	244,000	90,500	2.7:1
Lead	thousand short tons	([3])	([3])	2.9:1	8,780	553	15.9:1	8,780	553	15.9:1
Mercury	thousand flasks	16	1	29.4:1	14	2	8.8:1	30	2	14.0:1
Silver	thousand troy ounces	29	102	0.3:1	652	11,000	0.1:1	681	11,100	0.1:1
Titanium: Ilmenite	thousand short tons	32,300	804	40.2:1	--	--	--	32,300	804	40.2:1
Uranium	do	3,810	NA	NA	1,890	NA	NA	5,690	NA	NA
Zinc	do	W	W	W	[4] 6,670	[4] 327	[4] 20.4:1	6,670	327	20.4:1
NONMETALS										
Asbestos	do	[2] 2,720	[2] 150	[2] 18.1:1	W	W	W	2,720	150	18.1:1
Barite	do	3,560	946	3.8:1	158	158	1.0:1	3,720	1,100	3.4:1
Clays	do	57,900	57,900	1.0:1	817	817	1.0:1	58,700	58,700	1.0:1
Diatomite	do	609	609	1.0:1	--	--	--	609	609	1.0:1
Feldspar	do	[2] 1,900	[2] 773	[2] 2.5:1	W	W	W	1,900	773	2.5:1
Fluorspar	do	117	24	4.8:1	627	228	2.8:1	744	252	3.0:1
Gypsum	do	11,300	10,700	1.0:1	2,740	2,860	1.0:1	14,000	13,600	1.0:1
Mica (scrap)	do	392	144	2.7:1	--	--	--	392	144	2.7:1
Perlite	do	[2] 602	[2] 544	[2] 1.1:1	W	W	W	602	544	1.1:1
Phosphate rock	do	138,000	41,900	3.3:1	226	226	1.0:1	138,000	42,100	3.3:1
Potassium salts	do	--	--	--	17,100	2,170	7.9:1	17,100	2,170	7.9:1
Pumice	do	3,770	3,770	1.0:1	--	--	--	3,770	3,770	1.0:1
Salt	do	468	271	1.7:1	12,200	11,900	1.0:1	12,600	12,200	1.0:1
Sand and gravel	do	984,000	984,000	1.0:1	--	--	--	984,000	984,000	1.0:1
Sodium carbonate (natural)	do	--	--	--	6,460	3,440	1.9:1	6,460	3,440	1.9:1
Stone:										
Crushed and broken	do	1,020,000	1,020,000	1.0:1	40,500	40,200	1.0:1	1,060,000	1,060,000	1.0:1
Dimension	do	[e] 2,670	1,230	2.2:1	2	2	1.0:1	2,670	1,230	2.2:1
Talc, soapstone, pyrophyllite	do	831	713	1.2:1	474	533	1.0:1	1,310	1,250	1.1:1
Tripoli	do	[2] 102	[2] 102	[2] 1.0:1	W	W	W	102	102	1.0:1
Vermiculite	do	4,670	365	12.8:1	--	--	--	4,670	365	12.8:1

[e] Estimate. NA Not available. W Withheld to avoid disclosing individual company confidential data; included with "Surface or Underground."
[1] Data may not add to totals shown because of independent rounding.
[2] Includes underground data; the Bureau of Mines is not at liberty to publish separately.
[3] Less than ½ unit.
[4] Includes surface data; the Bureau of Mines is not at liberty to publish separately.

Table 11.—Material handled per unit of marketable product at surface and underground mines in the United States, by commodity, in 1973

Commodity	Unit of marketable product	Surface			Underground			Total [1]		
		Total material handled (thousand short tons)	Marketable product (units)	Ratio of units of material handled to units of marketable product	Total material handled (thousand short tons)	Marketable product (units)	Ratio of units of material handled to units of marketable product	Total material handled (thousand short tons)	Marketable product (units)	Ratio of units of material handled to units of marketable product
METALS										
Bauxite	thousand long tons	[2] 15,200	[2] 1,880	[2] 6.9:1	W	W	W	15,200	1,880	6.9:1
Copper	thousand short tons	1,040,000	1,410	681.4:1	36,100	288	121.3:1	1,080,000	1,690	586.2:1
Gold:										
Lode	thousand troy ounces	11,300	222	48.2:1	1,860	387	4.3:1	13,200	609	20.3:1
Placer	do	[2] 1,970	[2] 12	[2] 147.0:1	W	W	W	1,970	12	147.0:1
Iron ore	thousand long tons	488,000	83,500	5.2:1	12,700	7,070	1.6:1	501,000	90,500	4.9:1
Lead	thousand short tons	4	(3)	2.9:1	11,200	553	18.1:1	11,200	553	18.1:1
Mercury	thousand flasks	418	1	404.8:1	16	2	8.9:1	434	2	108.7:1
Silver	thousand troy ounces	66	102	0.3:1	1,060	11,000	0.1:1	1,130	11,100	0.1:1
Titanium: Ilmenite	thousand short tons	39,800	804	49.2:1	--	--	--	39,800	804	49.2:1
Uranium	do	205,000	NA	NA	2,820	NA	NA	208,000	NA	NA
Zinc	do	13	(3)	0.1:1	8,440	327	23.5:1	8,450	327	23.5:1
NONMETALS										
Asbestos	do	[2] 4,960	[2] 150	[2] 33.0:1	W	W	W	4,960	150	33.0:1
Barite	do	8,120	946	8.4:1	190	158	1.1:1	8,310	1,100	7.4:1
Clays	do	e 108,000	57,900	1.9:1	817	817	1.0:1	109,000	58,700	1.9:1
Diatomite	do	4,990	609	5.0:1	--	--	--	4,990	609	5.0:1
Feldspar	do	[2] 2,470	[2] 773	[2] 3.1:1	W	W	W	2,470	773	3.1:1
Fluorspar	do	108	24	4.1:1	683	228	2.7:1	791	252	2.8:1
Gypsum	do	25,500	10,700	1.4:1	2,850	2,860	1.0:1	28,400	13,600	1.3:1
Mica (scrap)	do	3,950	144	27.0:1	--	--	--	3,950	144	27.0:1
Perlite	do	[2] 874	[2] 544	[2] 1.6:1	W	W	W	874	544	1.6:1
Phosphate rock	do	372,000	41,900	8.7:1	255	226	1.0:1	372,000	42,100	8.7:1
Potassium salts	do	--	--	--	17,400	2,170	8.0:1	17,400	2,170	8.0:1
Pumice	do	4,290	3,770	1.1:1	--	--	--	4,290	3,770	1.1:1
Salt	do	543	271	2.0:1	12,900	11,900	1.1:1	13,400	12,200	1.1:1
Sand and gravel	do	984,000	984,000	1.0:1	--	--	--	984,000	984,000	1.0:1
Sodium carbonate (natural)	do	--	--	--	6,540	3,440	1.9:1	6,540	3,440	1.9:1
Stone:										
Crushed and broken	do	e 1,100,000	1,020,000	1.1:1	e 40,800	40,200	1.0:1	1,140,000	1,060,000	1.1:1
Dimension	do	e 4,080	1,230	3.3:1	2	2	1.0:1	4,080	1,230	3.3:1
Talc, soapstone, pyrophyllite	do	2,930	713	2.3:1	560	533	0.9:1	3,490	1,250	1.7:1
Tripoli	do	[2] 102	[2] 102	[2] 1.0:1	W	W	W	102	102	1.0:1
Vermiculite	do	7,460	365	20.4:1	--	--	--	7,460	365	20.4:1

e Estimate. NA Not available. W Withheld to avoid disclosing individual company confidential data; included with "Surface."
[1] Data may not add to totals shown because of independent rounding.
[2] Includes underground data; the Bureau of Mines is not at liberty to publish separately.
[3] Less than ½ unit.

Table 12.—Mining methods used in open-pit mining, by commodity, in 1973

(Percent)

Commodity	Total material handled	
	Preceded by drilling and blasting	Not preceded by drilling and blasting[1]
METALS		
Bauxite	56	44
Beryllium	--	100
Copper	85	15
Gold:		
Lode	98	2
Placer	--	100
Iron ore	84	16
Lead	--	100
Mercury	30	70
Molybdenum	100	--
Nickel	12	88
Platinum-group metals	--	100
Rare-earth metals	100	--
Silver	99	1
Tin	--	100
Titanium: Ilmenite	10	90
Tungsten	100	--
Uranium	11	89
Vanadium	50	50
NONMETALS		
Abrasives:		
Abrasive stone	66	34
Emery	100	--
Garnet	59	41
Tripoli	92	8
Aplite	41	59
Asbestos	91	9
Barite	15	85
Boron	100	--
Clays	--	100
Diatomite	--	100
Feldspar	77	23
Fluorspar	100	--
Graphite	100	--
Greensand marl	--	100
Gypsum	85	15
Iron oxide pigments (crude)	--	100
Kyanite	79	21
Magnesite	100	--
Mica (scrap)	48	52
Mica (sheet)	--	100
Millstone	98	2
Olivine	59	41
Perlite	45	55
Phosphate rock	4	96
Pumice	--	100
Salt	4	96
Sand and gravel	--	100
Stone:		
Crushed and broken	98	2
Dimension	--	100
Talc, soapstone, pyrophyllite	68	32
Vermiculite	62	38
Total	55	45

[1] Includes drilling or cutting without blasting, dredging, mechanical excavation and nonfloat washing, and other surface mining methods.

Table 13.—Exploration and development activity in the United States, by method, in 1973

Method	Metals		Nonmetals		Total [1]	
	Feet	Percent of total [2]	Feet	Percent of total [2]	Feet	Percent of total [2]
DEVELOPMENT						
Shaft and winze sinking	8,450	1.2	850	1.7	9,290	1.2
Raising	126,000	17.2	7,580	15.0	133,000	17.0
Drifting, crosscutting or tunneling	597,000	81.6	42,000	83.3	639,000	81.8
Total [1]	731,000	100.0	50,400	100.0	782,000	100.0
EXPLORATION						
Diamond drilling	1,490,000	7.6	133,000	25.6	1,620,000	8.1
Churn drilling	109,000	.6	5,000	1.0	114,000	.6
Rotary drilling	12,400,000	63.6	278,000	53.8	12,700,000	63.3
Percussion drilling	4,670,000	23.9	65,500	12.7	4,730,000	23.6
Other drilling	794,000	4.1	28,200	5.4	822,000	4.1
Trenching	49,600	.2	8,020	1.5	57,600	.3
Total [1]	19,500,000	100.0	517,000	100.0	20,000,000	100.0
Grand total [1]	20,300,000		568,000		20,800,000	

[1] Data may not add to totals shown because of independent rounding.
[2] Based on unrounded footage.

Table 14.—Exploration and development by method and selected metals and nonmetals, in 1973

(Feet)

Commodity	Development				Exploration						
	Shaft and winze sinking	Raising	Drifting, cross-cutting or tunneling	Total [1]	Diamond drilling	Churn drilling	Rotary drilling	Percussion drilling	Other drilling	Trenching	Total [1]
METALS											
Copper	1,360	73,700	144,000	219,000	603,000	4,200	181,000	75,100	60,500	13,900	938,000
Gold	610	9,110	44,300	54,000	72,500	1,700	72,100	4,040,000	18,400	16,900	4,230,000
Iron ore	100	2,040	60,100	62,200	97,800	--	133,000	7,880	862	80	239,000
Lead	247	8,790	52,800	61,800	172,000	38,300	956	7,520	53,600	1,590	274,000
Mercury	--	--	430	430	--	--	--	50	--	1,000	1,050
Silver	595	7,410	22,000	30,000	24,000	850	525	17,900	45,900	5,020	94,200
Tungsten	--	1,260	6,730	7,980	24,900	--	1,600	8,330	--	6,700	41,500
Uranium	3,030	8,890	128,000	140,000	28,400	--	11,600,000	373,000	438,000	4,000	12,400,000
Zinc	1,350	13,500	79,600	94,500	289,000	--	--	85,000	1,610	300	376,000
Other [2]	1,150	849	59,600	61,600	180,000	64,000	427,000	46,400	175,000	100	893,000
Total [1]	8,450	126,000	597,000	731,000	1,490,000	109,000	12,400,000	4,670,000	794,000	49,600	19,500,000
NONMETALS											
Asbestos	--	--	--	--	--	--	600	--	--	25	625
Barite	--	60	2,010	2,070	122	--	6,960	55,600	20,300	7,370	90,400
Fluorspar	391	5,220	10,000	15,600	121,000	--	--	100	--	--	121,000
Gypsum	368	--	7,510	7,880	--	--	--	--	4,030	--	4,030
Phosphate rock	--	1,490	6,140	7,630	--	--	151,000	--	--	60	151,000
Talc, soapstone, pyrophyllite	--	777	5,350	6,130	2,870	5,000	--	6,000	--	--	13,900
Other [3]	89	38	11,000	11,100	8,600	--	119,000	3,730	3,850	560	136,000
Total [1]	850	7,580	42,000	50,400	133,000	5,000	278,000	65,500	28,200	8,020	517,000
Grand total [1]	9,290	133,000	639,000	782,000	1,620,000	114,000	12,700,000	4,730,000	822,000	57,600	20,000,000

[1] Data may not add to totals shown because of independent rounding.
[2] Bauxite, columbium and tantalum, molybdenum, tin, and vanadium.
[3] Boron, bromine, diatomite, feldspar, iron oxide pigments (crude), lithium, mica (scrap), millstones, olivine, potassium salt, pumice, salts, sodium carbonate (natural), stone (dimension), tripoli, and wollastonite.

Table 15.—Exploration and development by method and State, in 1973

(Feet)

State	Development				Exploration						
	Shaft and winze sinking	Raising	Drifting, cross-cutting or tunneling	Total [1]	Diamond drilling	Churn drilling	Rotary drilling	Percussion drilling	Other drilling	Trenching	Total [1]
Alabama	--	--	--	--	48,900	69,000	330,000	--	--	--	448,000
Alaska	--	--	458	458	24,100	1,700	6,000	250	3,200	11,000	46,200
Arizona	1,010	65,400	119,000	185,000	364,000	4,200	114,000	32,100	26,200	2,630	543,000
Arkansas	--	30	1,880	1,910	--	--	24,600	14	470	--	25,100
California	316	1,140	10,200	11,600	63,500	--	40,500	13,900	686	6,320	125,000
Colorado	373	10,000	98,500	109,000	158,000	850	166,000	66,600	142,000	5,920	539,000
Florida	--	--	--	--	--	--	116,000	--	--	--	116,000
Georgia	--	--	--	--	11,900	--	21,000	--	--	--	33,000
Idaho	1,820	13,400	44,700	59,900	22,900	--	31,700	4,710	4,490	2,990	66,800
Illinois	391	2,220	6,600	9,210	107,000	--	--	--	--	--	107,000
Indiana	368	--	--	368	--	--	--	--	--	--	--
Iowa	--	--	--	--	--	--	--	--	4,030	--	4,030
Kentucky	--	300	1,000	1,300	70,900	--	--	--	--	--	70,900
Louisiana	--	--	--	--	--	--	3,000	--	--	--	3,000
Maine	--	--	12,200	12,200	40,000	--	--	--	--	--	40,000
Michigan	--	--	4,780	4,780	3,600	--	--	--	--	--	3,600
Minnesota	--	--	--	--	55,400	--	2,050	--	--	--	57,500
Missouri	100	2,550	75,400	78,000	191,000	38,300	--	13,600	65,100	3,930	312,000
Montana	428	8,890	24,700	34,000	35,100	--	122,000	19,800	68,000	2,620	247,000
Nebraska	--	--	--	--	1,720	--	675	--	--	--	2,400
Nevada	465	2,970	7,420	10,900	29,000	--	93,500	117,000	36,400	20,500	296,000
New Mexico	2,640	3,840	108,000	114,000	66,400	--	2,940,000	303,000	419,000	85	3,720,000
New York	--	5,970	25,000	31,000	2,470	--	--	--	--	--	2,470
North Carolina	--	--	181	181	3,490	--	10,400	2,000	1,200	--	17,100
North Dakota	--	--	--	--	--	--	82,100	--	--	--	82,100
Ohio	--	--	--	--	1,210	--	--	--	--	--	1,210
Oklahoma	--	--	--	--	--	--	7,150	--	--	460	7,610
Oregon	--	68	877	945	180	--	--	--	1,500	130	1,810
Pennsylvania	167	628	6,340	7,140	--	--	600	--	--	--	600
South Dakota	24	8,510	36,600	45,100	49,700	--	141,000	4,000,000	--	--	4,190,000
Tennessee	240	248	11,500	12,000	115,000	--	3,000	75,200	--	--	193,000
Texas	--	--	--	--	--	--	3,120,000	--	--	--	3,120,000
Utah	872	5,620	16,900	23,400	107,000	--	122,000	9,530	44,900	1,000	284,000
Vermont	--	250	750	1,000	--	--	--	--	--	--	--
Virginia	--	678	8,460	9,140	--	--	--	--	--	--	--
Washington	--	377	5,890	6,270	27,500	--	--	6	100	10	27,600
Wisconsin	--	--	--	--	16,400	--	967	--	--	--	17,400
Wyoming	82	38	11,900	12,000	7,580	--	5,190,000	75,300	5,100	--	5,280,000
Total [1]	9,290	133,000	639,000	782,000	1,620,000	114,000	12,700,000	4,730,000	822,000	57,600	20,000,000

[1] Data may not add to totals shown because of independent rounding.

Table 16.—Total material (ore and waste) produced by mine development in the United States, by commodity and State, in 1973

(Thousand short tons)

	Shaft and winze sinking	Raising	Drifting, crosscutting, or tunneling	Stripping	Total [1]
COMMODITY					
METALS					
Copper	30	185	961	84,500	85,700
Gold:					
Lode	2	33	172	648	855
Placer	--	--	5	206	211
Iron ore	1	31	1,360	51,600	53,000
Lead	4	37	1,130	4	1,170
Mercury	--	--	2	200	202
Silver	4	27	342	36	410
Tungsten	--	4	83	--	87
Uranium	36	74	522	45,100	45,700
Zinc	15	48	707	13	783
Other [2]	5	26	789	18,500	19,300
Total metals [1]	97	466	6,070	201,000	207,000
NONMETALS					
Barite	--	--	15	170	186
Diatomite	--	--	--	1,940	1,940
Feldspar	--	--	1	100	101
Fluorspar	3	22	51	10	86
Gypsum	7	--	64	10,900	10,900
Mica (scrap)	--	--	--	77	77
Phosphate rock	--	7	22	6,890	6,920
Pumice	--	--	--	22	22
Talc, soapstone, pyrophyllite	--	3	66	1,290	1,350
Other [3]	1	--	78	1,600	1,680
Total nonmetals [1]	11	32	297	22,900	23,300
Grand total [1]	108	498	6,370	224,000	231,000
STATE					
Alabama	--	--	--	W	W
Alaska	--	--	2	189	192
Arizona	28	153	861	45,900	47,000
Arkansas	--	(4)	15	2,710	2,720
California	1	3	106	3,260	3,370
Colorado	2	58	1,240	2,770	4,080
Connecticut	--	--	--	W	W
Florida	--	--	--	W	W
Georgia	--	--	--	W	W
Idaho	13	66	268	10	357
Illinois	3	12	39	--	54
Indiana	W	--	--	--	W
Iowa	--	--	--	W	W
Kentucky	--	W	W	--	W
Maine	--	--	W	--	W
Michigan	--	--	21	13,200	13,200
Minnesota	--	--	--	39,900	39,900
Missouri	1	17	1,890	78	1,990
Montana	2	33	81	602	718
Nevada	3	11	74	4,360	4,450
New Mexico	34	44	450	51,800	52,300
New York	--	9	145	226	380
North Carolina	--	--	(4)	42	42
Oklahoma	--	--	--	W	W
Oregon	--	1	4	1	6
Pennsylvania	W	W	W	W	W
South Dakota	(4)	30	138	(4)	168
Tennessee	3	1	153	--	157
Texas	--	--	--	2,350	2,350
Utah	4	35	108	5,660	5,810
Vermont	--	W	W	--	W
Virginia	--	1	69	7	78
Washington	--	3	82	28	113
Wyoming	2	(4)	86	46,500	46,600
Undistributed	12	22	531	4,170	4,740
Total [1]	108	498	6,370	224,000	231,000

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Data may not add to totals shown because of independent rounding.

[2] Bauxite, beryllium, molybdenum, titanium (ilmenite) and vanadium.

[3] Abrasive stone, asbestos, boron minerals, garnet, magnesite, mica (sheet), potassium salts, salt, and sodium carbonate (natural).

[4] Less than ½ unit.

Table 17.—U.S. consumption of explosives

(Thousand pounds)

Year	Coal mining	Metal mining	Quarrying and nonmetal mining	Total mineral industry	Other	Total industrial
1969	820,114	470,791	438,789	1,729,694	496,783	2,226,477
1970	962,331	479,508	455,424	1,897,263	496,228	2,393,491
1971	1,071,305	457,286	489,572	2,018,163	535,851	2,554,014
1972	1,212,585	430,686	493,677	2,136,948	532,841	2,669,789
1973	1,177,062	495,879	643,292	2,316,233	438,713	2,754,946

Table 18.—U.S. consumption of explosives in the minerals industry

(Thousand pounds)

Year	Coal mining	Metal mining	Quarrying and nonmetal mining	Total
PERMISSIBLE EXPLOSIVES				
1972	42,232	99	865	43,196
1973	39,307	115	957	40,379
OTHER HIGH EXPLOSIVES				
1972	16,297	27,648	100,600	144,545
1973	20,198	28,295	107,675	156,168
CYLINDRICALLY-PACKED BLASTING AGENTS				
1972	201,820	7,542	30,064	239,426
1973	222,797	6,265	32,228	261,290
PACKAGED AND BULK WATER GELS AND SLURRIES				
1972	9,212	156,618	41,305	207,135
1973	11,622	173,530	54,154	239,306
OTHER PROCESSED BLASTING AGENTS AND UNPROCESSED AMMONIUM NITRATE				
1972	943,024	238,779	320,843	1,502,646
1973	883,138	287,674	448,278	1,619,090
TOTAL EXPLOSIVES				
1972	1,212,585	430,686	493,677	2,136,948
1973	1,177,062	495,879	643,292	2,316,233

Statistical Summary

By Staff, Office of Technical Data Services—Mineral Supply

This chapter summarizes mineral production data for the United States, its island possessions, and the Commonwealth of Puerto Rico. Tables are also included that show the principal mineral commodities exported from and imported into the United States, and that compare world and U.S. mineral production. The detailed data from which these tables were derived are contained in the commodity chapters of volume I and in the State chapters of volume II of this edition of the Minerals Yearbook.

Mineral production may be measured at any of several stages of extraction and processing. The stage of measurement used in this chapter is what is normally termed "mine output." It usually refers to minerals or ores in the form in which they are first extracted from the ground, but customarily includes the product of auxiliary processing at or near the mines.

Because of inadequacies in the statistics available, some series deviate from the foregoing definition. In the case of gold, silver, copper, lead, zinc, and tin, the quantities are recorded on a mine basis (as the recoverable content of ore sold or treated). However, the values assigned to these quantities are based on the average selling price of refined metal, not the mine value. Mercury is measured as recovered metal and valued at the average New York price for the metal.

The weight of volume units shown are those customarily used in the particular industries producing the commodities. Values shown are in current dollars, with no adjustment made to compensate for changes in the purchasing power of the dollar.

Table 1.—Value of mineral production[1] in the United States, by mineral group

(Millions)

Year	Mineral fuels	Nonmetals (except fuels)	Metals	Total[2]
1969	$17,965	$5,624	$3,333	$26,921
1970	20,152	5,712	3,928	29,792
1971	21,247	6,058	3,403	30,708
1972 r	22,061	6,482	3,642	32,185
1973	25,012	7,413	4,362	36,788

r Revised.

1 Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

2 Data may not add to totals shown because of independent rounding.

Table 2.—Mineral production [1] in the United States

Mineral	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)	1972 Quantity	1972 Value (thousands)	1973 Quantity	1973 Value (thousands)
MINERAL FUELS								
Asphalt and related bitumens (native): Bituminous limestone, sandstone, gilsonite ....short tons....	1,980,562	$8,879	1,668,928	$8,291	1,995,374	$10,303	2,088,657	$8,464
Carbon dioxide, natural ....thousand cubic feet..	1,109,530	191	1,271,995	216	1,228,741	165	1,134,986	259
Coal:								
Bituminous and lignite [2] ....thousand short tons..	602,932	3,772,662	552,192	3,901,496	595,386	4,561,983	591,738	5,049,612
Pennsylvania anthracite ....do....	9,729	105,341	8,727	103,469	7,106	85,251	6,830	90,260
Helium:								
Crude ....million cubic feet..	3,953	46,820	3,988	47,856	r 3,467	r 41,604	2,558	30,696
High purity ....do....	647	17,405	577	14,539	r 629	r 15,673	647	16,121
Natural gas ....do....	21,920,642	3,745,680	22,493,012	4,085,482	22,531,698	r 4,180,462	22,647,549	4,894,072
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels..	206,305	603,024	200,181	616,657	193,480	604,423	187,390	668,784
LPG ....do....	399,611	672,088	417,634	769,397	444,736	847,810	447,033	1,188,289
Peat ....thousand short tons..	526	5,986	600	7,011	607	7,112	621	7,547
Petroleum (crude) ....thousand 42-gallon barrels..	3,517,450	11,173,726	3,453,914	11,692,998	3,455,368	11,706,510	3,360,903	13,057,905
Total mineral fuels	XX	20,152,000	XX	21,247,000	XX	r 22,061,000	XX	25,012,000
NONMETALS (EXCEPT FUELS)								
Abrasive stones [3] ....short tons..	3,055	635	2,349	563	3,241	670	3,466	667
Asbestos ....do....	125,314	10,696	130,882	12,174	131,663	13,408	150,036	16,288
Barite ....thousand short tons..	854	12,800	825	13,491	906	14,883	1,104	16,688
Boron minerals ....do....	1,041	86,827	1,047	89,856	1,121	95,882	1,225	113,648
Bromine ....thousand pounds..	349,748	60,560	355,946	61,750	386,864	63,689	418,250	67,131
Calcium-magnesium chloride ....short tons..	632,500	15,225	W	W	W	W	609,300	17,581
Cement:								
Portland ....thousand short tons..	71,629	1,268,718	75,881	1,421,388	77,973	1,588,290	82,718	1,810,292
Masonry ....do....	2,978	67,537	3,341	84,556	3,777	100,269	4,057	119,547
Clays ....do....	54,853	267,912	56,666	274,431	59,456	303,022	64,351	354,058
Diatomite ....short tons..	597,636	32,649	535,318	34,392	576,089	37,554	608,906	36,083
Emery ....do....	W	W	W	W	2,883	W	2,884	W
Feldspar ....do....	726,069	9,638	742,810	9,969	r 746,212	r 10,623	791,900	12,830
Fluorspar ....do....	269,221	13,923	272,071	17,263	250,347	17,315	248,601	17,337
Garnet (abrasive) ....do....	18,837	1,936	18,984	1,934	18,916	1,957	22,772	2,381
Gem stones [e]	NA	2,396	NA	2,589	NA	2,728	NA	2,739
Gypsum ....thousand short tons..	9,436	35,132	10,418	39,057	12,328	48,504	13,558	56,650
Lime ....do....	19,747	286,155	19,591	308,100	20,290	339,304	21,090	365,849
Magnesium compounds from sea water and brine (except for metal) ....short tons, MgO equivalent..	707,874	62,434	668,649	62,322	729,472	63,915	853,907	77,733
Mica:								
Scrap ....thousand short tons..	119	2,527	127	2,917	160	4,353	177	6,082
Sheet ....pounds..	--	--	17,005	7	14,280	7	--	--
Perlite ....short tons..	456,134	4,904	432,208	4,941	544,594	6,231	543,683	5,591
Phosphate rock ....thousand short tons..	38,739	203,218	38,886	203,828	40,831	207,910	42,137	238,667
Potassium salts ....thousand short tons, K_2O equivalent..	2,729	98,123	2,587	100,527	2,659	106,680	2,603	112,613
Pumice ....thousand short tons..	3,036	4,671	3,391	5,214	3,813	6,539	3,772	8,770
Pyrites ....thousand long tons..	W	W	808	7,137	741	6,652	559	4,961
Salt ....thousand short tons..	45,896	304,759	44,077	303,687	45,022	296,772	43,910	306,103
Sand and gravel ....do....	943,941	1,115,705	919,593	1,148,969	r 914,324	r 1,200,701	983,629	1,359,370

Sodium carbonate (natural) do	2,688	56,320	2,878	60,774	3,218	71,689	3,722	94,385
Sodium sulfate (natural) do	602	10,932	688	11,008	701	11,396	672	11,597
Stone[4] do	874,512	1,474,917	876,123	1,594,065	r 920,423	r 1,672,293	1,060,124	1,990,463
Sulfur: Frasch process thousand long tons	6,419	151,779	6,738	117,894	7,613	132,385	7,438	138,578
Talc, soapstone, pyrophyllite short tons	1,027,929	7,773	1,037,297	7,634	1,107,404	r 7,828	1,246,534	9,144
Tripoli do	68,105	520	75,134	569	87,864	797	101,519	930
Vermiculite thousand short tons	285	6,501	301	7,198	337	8,092	365	9,464
Value of items that cannot be disclosed: Aplite, brucite (1970–71), natural and slag cement, graphite, iodine, kyanite, lithium minerals, magnesite, greensand marl, olivine, staurolite, wollastonite, and values of nonmetal items indicated by symbol W	XX	34,401	XX	47,358	XX	39,730	XX	28,926
Total nonmetals	XX	5,712,000	XX	6,058,000	XX	r 6,482,000	XX	7,413,000
METALS								
Antimony ore and concentrate short tons, antimony content	1,130	W	1,025	933	489	386	545	688
Bauxite thousand long tons, dried equivalent	2,082	30,070	1,988	28,543	1,812	23,238	1,879	26,635
Copper (recoverable content of ores, etc.) short tons	1,719,657	1,984,484	1,522,183	1,583,071	1,664,840	1,704,796	1,717,940	2,044,346
Gold (recoverable content of ores, etc.) troy ounces	1,743,322	63,439	1,495,108	61,673	1,449,943	84,967	1,175,750	115,000
Iron ore, usable (excluding byproduct iron sinter) thousand long tons, gross weight	87,176	941,739	77,106	891,002	77,884	950,365	90,654	1,163,710
Lead (recoverable content of ores, etc.) short tons	571,767	178,609	578,550	159,679	618,915	186,046	603,024	196,465
Manganese ore (35% or more Mn) short tons, gross weight	4,737	W	142	W	578	W	239	W
Manganiferous ore (5% to 35% Mn) do	368,302	W	198,334	W	147,161	W	203,055	W
Mercury 76-pound flasks	27,296	11,130	17,883	5,229	r 7,333	r 1,601	2,171	621
Molybdenum (content of concentrate) thousand pounds	110,381	190,077	97,882	164,917	102,197	170,530	135,097	217,701
Nickel (content of ore and concentrate) short tons	15,933	W	17,036	W	16,864	W	18,272	W
Rare-earth metal concentrates do	W	W	17,194	7,538	19,520	8,479	31,278	13,780
Silver (recoverable content of ores, etc.) thousand troy ounces	45,006	79,697	41,564	64,258	37,233	62,737	37,827	96,762
Titanium concentrate, ilmenite short tons, gross weight	920,964	18,626	713,610	15,936	r 739,801	r 16,739	804,355	19,829
Tungsten ore and concentrate thousand pounds contained W	r 9,312	23,790	r 6,827	20,184	r 7,045	18,104	7,059	19,154
Uranium (recoverable content U_3O_8) thousand pounds	24,682	149,464	24,515	151,996	25,758	162,272	25,820	167,830
Vanadium (recoverable in ore and concentrate) short tons	5,319	34,923	5,252	37,690	4,887	30,867	4,377	26,611
Zinc (recoverable content of ores, etc.) do	534,136	163,650	491,407	158,234	478,318	169,803	478,850	197,861
Value of items that cannot be disclosed: Beryllium, cobalt (1970–71), magnesium chloride for magnesium metal, manganiferous residuum, platinum-group metals (crude), tin (content of concentrate), titanium concentrate (rutile 1972–73), zircon concentrate, and value of metal items indicated by symbol W	XX	58,430	XX	51,690	XX	r 50,650	XX	55,216
Total metals	XX	3,928,000	XX	3,403,000	XX	r 3,642,000	XX	4,362,000
Grand total mineral production	XX	29,792,000	XX	30,708,000	XX	r 32,185,000	XX	36,788,000

e Estimate. r Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data; included with "Value of items that cannot be disclosed." XX Not applicable.

1 Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

2 Includes a small quantity of anthracite mined in States other than Pennsylvania. In 1971, value excluded that of Arizona, which is withheld to avoid disclosing individual company confidential data; value included with "Nonmetal items that cannot be disclosed."

3 Grindstones, pulpstones, grinding pebbles, sharpening stones, and tube mill liners.

4 Excludes abrasive stone, bituminous limestone, bituminous sandstone, and soapstone, all included elsewhere in table.

Table 3.—Minerals produced in the United States and principal producing States in 1973

Mineral	Principal producing States, in order of quantity	Other producing States
Antimony ore and concentrate	Idaho, Mont., Nev.	
Aplite	Va.	
Asbestos	Calif., Vt., Ariz., N.C.	
Asphalt (native)	Tex., Utah, Ala., Mo.	
Barite	Nev., Mo., Ark., Alaska	Calif., Ga., Tenn.
Bauxite	Ark., Ala., Ga.	
Beryllium concentrate	Utah.	
Boron minerals	Calif.	
Bromine	Ark., Mich., Calif.	
Calcium-magnesium chloride	Mich., Calif.	
Carbon dioxide (natural)	N. Mex., Calif., Colo., Utah.	
Cement	Calif., Pa., Tex., Mich	Ala., Ariz., Ark., Colo., Fla., Ga., Hawaii, Idaho, Ill., Ind., Iowa, Kans., Ky., La., Maine, Md., Minn., Miss., Mo., Mont., Nebr., Nev., N. Mex., N.Y., N.C., Ohio, Okla., Oreg., S.C., S. Dak., Tenn., Utah, Va., Wash., W. Va., Wis., Wyo.
Clays	Ga., Tex., Ohio, N.C	All other States except Alaska, R.I., Vt.
Coal	Ky., W. Va., Pa., Ill	Ala., Alaska, Ariz., Ark., Colo., Ind., Iowa, Kans., Md., Mo., Mont., N. Mex., N. Dak., Ohio, Okla., Tenn., Tex., Utah, Va., Wash., Wyo.
Copper (mine)	Ariz., Utah, N. Mex., Mont	Calif., Colo., Idaho, Maine, Mich., Mo., Nev., Okla., Oreg., Pa., Tenn., Wash.
Diatomite	Calif., Nev., Wash	Oreg.
Emery	N.Y	Oreg.
Feldspar	N.C., Calif., Conn., Ga	Ariz., Colo., S. Dak., Wyo.
Fluorspar	Ill., Colo., Mont., Nev	Ariz., Ky., Tex., Utah.
Garnet, abrasive	N.Y., Idaho.	
Gold (mine)	S. Dak., Utah, Nev., Ariz	Alaska, Calif., Colo., Idaho, Mont., N. Mex., Oreg., Tenn., Wash.
Graphite	Tex.	
Gypsum	Mich., Calif., Tex., Iowa	Ariz., Ark., Colo., Idaho, Ind., Kans., La., Mont., Nev., N. Mex., N.Y., Ohio, Okla., S. Dak., Utah, Va., Wash., Wyo.
Helium	Kans., Tex., Okla., Ariz.	
Iodine	Mich.	
Iron ore	Minn., Mich., Calif., Mo	Ala., Ariz., Ark., Colo., Ga., Idaho, Mont., Nev., N. Mex., N.Y., N.C., Pa., Tex., Utah, Wis., Wyo.
Kyanite	Va., Ga., Fla.	
Lead (mine)	Mo., Idaho, Colo., Utah	Alaska, Ariz., Calif., Ill., Maine, Mont., N. Mex., N.Y., Va., Wash., Wis.
Lime	Ohio, Pa., Tex., Mo	Ala., Ariz., Ark., Calif., Colo., Conn., Fla., Hawaii, Idaho, Ill., Ind., Iowa, Kans., Ky., La., Md., Mass., Mich., Minn., Miss., Mont., Nebr., Nev., N.J., N. Mex., N.Y., N. Dak., Okla., Oreg., S. Dak., Tenn., Utah, Va., Wash., W. Va., Wis., Wyo.
Lithium minerals	N.C., Nev., Calif.	
Magnesite	Nev.	
Magnesium chloride	Tex.	
Magnesium compounds	Mich., Calif., N.J., Fla	Del., Miss., Tex., Utah.
Manganese ore	Mont.	
Manganiferous ore	Minn., N. Mex.	
Manganiferous residuum	N.J.	
Marl, greensand	N.J.	
Mercury	Calif., Nev., Alaska, Tex	Oreg.
Mica, scrap	N.C., Ala., Ga., S.C	Ariz., Conn., N. Mex.
Molybdenum	Colo., Ariz., Utah, N. Mex	Calif., Nev.
Natural gas	Tex., La., Okla., N. Mex	Ala., Alaska, Ariz., Ark., Calif., Colo., Fla., Ill., Ind., Kans., Ky., Md., Mich., Miss., Mo., Mont., Nebr., N.Y., N. Dak., Ohio, Pa., Tenn., Utah, Va., W. Va., Wyo.

Table 3.—Minerals produced in the United States and principal producing States in 1973—Continued

Mineral	Principal producing States, in order of quantity	Other producing States
Natural gas liquids	Tex., La., Okla., N. Mex.	Ala., Alaska, Ark., Calif., Colo., Fla., Ill., Kans., Ky., Mich., Miss., Mont., Nebr., N. Dak., Pa., Utah, W. Va., Wyo.
Nickel	Oreg.	
Olivine	Wash., N.C.	
Peat	Mich., Ill., Ind., N.J.	Calif., Colo., Fla., Ga., Iowa, Maine, Md., Mass., Minn., Mont., N. Mex., N.Y., Ohio, Pa., S.C., Vt., Wash., Wis.
Perlite	N. Mex., Ariz., Calif., Nev.	Colo., Idaho, Tex.
Petroleum, crude	Tex., La., Calif., Okla.	Ala., Alaska, Ariz., Ark., Colo., Fla., Ill., Ind., Kans., Ky., Mich., Miss., Mo., Mont., Nebr., Nev., N. Mex., N.Y., N. Dak., Ohio, Pa., S. Dak., Tenn., Utah, W. Va., Wyo.
Phosphate rock	Fla., Idaho, Tenn., N.C.	Mo., Mont., Utah, Wyo.
Platinum-group metals	Alaska.	
Potassium salts	N. Mex., Utah, Calif.	
Pumice	Oreg., Ariz., Calif., Hawaii	Colo., Idaho, Kans., Nev., N. Mex., Okla., Utah, Wash., Wyo.
Pyrites ore and concentrate	Tenn., Colo., Ariz.	
Rare-earth metal concentrate	Calif., Ga., Fla.	
Salt	La., Tex., N.Y., Mich.	Ala., Calif., Colo., Hawaii, Kans., Nev., N. Mex., N. Dak., Ohio, Okla., Utah, Va., W. Va.
Sand and gravel	Calif., Mich., Ohio, Ill.	All other States.
Silver (mine)	Idaho, Ariz., Mont., Colo.	Alaska, Calif., Ill., Maine, Mich., Mo., Nev., N. Mex., N.Y., Okla., Oreg., S. Dak., Tenn., Utah, Wash.
Sodium carbonate (natural)	Wyo., Calif.	
Sodium sulfate (natural)	Calif., Tex., Utah.	
Staurolite	Fla.	
Stone	Pa., Ill., Fla., Tex.	All other States except Del.
Sulfur (Frasch)	Tex., La.	
Talc, soapstone, pyrophyllite	Vt., N.Y., Tex., Mont.	Ala., Ark., Calif., Ga., Md., Nev., N.C., Oreg., Va., Wash.
Tin	Colo., N. Mex.	Alaska.
Titanium concentrate	N.Y., Fla., N.J., Ga.	
Tripoli	Ill., Okla., Ark., Pa.	
Tungsten concentrate	Calif, Colo., Nev.	Ariz., Idaho, Mont., Utah, Wash.
Uranium	Wyo., N. Mex., Tex., Utah	Alaska, Colo., Wash.
Vanadium	Ark., Idaho, Colo., Utah	N. Mex.
Vermiculite	Mont., S.C.	
Wollastonite	N.Y.	
Zinc (mine)	Mo., N.Y., Tenn., Colo.	Ariz., Calif., Idaho, Ill., Ky., Maine, Mont., N.J., N. Mex., Pa., Utah, Va., Wash., Wis.
Zircon concentrate	Fla., Ga.	

Table 4.—Value of mineral production in the United States and principal minerals produced in 1973

State	Value (thousands)	Rank	Percent of U.S. total	Principal minerals, in order of value
Alabama	$413,056	21	1.12	Coal, cement, petroleum, stone.
Alaska	328,789	25	.89	Petroleum, sand and gravel, natural gas, stone.
Arizona	1,304,988	8	3.55	Copper, molybdenum, sand and gravel, cement.
Arkansas	273,705	29	.75	Petroleum, bromine, natural gas, cement.
California	2,041,686	3	5.55	Petroleum, cement, sand and gravel, natural gas.
Colorado	532,776	19	1.45	Petroleum, molybdenum, coal, sand and gravel.
Connecticut	36,804	44	.10	Stone, sand and gravel, feldspar, lime.
Delaware	3,889	50	.01	Sand and gravel, magnesium compounds, clays.
Florida	601,100	17	1.63	Phosphate rock, petroleum, stone, cement.
Georgia	305,479	26	.83	Clays, stone, cement, sand and gravel.
Hawaii	35,147	45	.10	Stone, cement, sand and gravel, pumice.
Idaho	136,081	33	.37	Silver, phosphate rock, lead, zinc.
Illinois	825,608	12	2.24	Coal, petroleum, stone, sand and gravel.
Indiana	351,405	24	.96	Coal, cement, stone, sand and gravel.
Iowa	158,800	31	.43	Cement, stone, sand and gravel, gypsum.
Kansas	646,299	16	1.76	Petroleum, natural gas, natural gas liquids, cement.
Kentucky	1,164,762	9	3.17	Coal, stone, petroleum, natural gas.
Louisiana	5,819,610	2	15.82	Petroleum, natural gas, natural gas liquids, sulfur.
Maine	33,493	46	.09	Sand and gravel, cement, zinc, stone.
Maryland	131,907	34	.36	Stone, cement, sand and gravel, coal.
Massachusetts	59,682	43	.16	Stone, sand and gravel, lime, clays.
Michigan	789,022	14	2.14	Iron ore, cement, copper, sand and gravel.
Minnesota	852,785	11	2.32	Iron ore, sand and gravel, stone, cement.
Mississippi	281,738	27	.77	Petroleum, natural gas, sand and gravel, cement.
Missouri	512,634	20	1.39	Lead, cement, stone, iron ore.
Montana	385,285	22	1.05	Copper, petroleum, coal, sand and gravel.
Nebraska	80,821	42	.22	Petroleum, cement, sand and gravel, stone.
Nevada	201,813	30	.55	Copper, gold, sand and gravel, diatomite.
New Hampshire	14,119	48	.04	Sand and gravel, stone, clays, gem stones.
New Jersey	114,016	37	.31	Stone, sand and gravel, zinc, titanium concentrate.
New Mexico	1,305,644	7	3.55	Petroleum, natural gas, copper, natural gas liquids.
New York	375,866	23	1.02	Cement, stone, salt, sand and gravel.
North Carolina	146,930	32	.40	Stone, sand and gravel, cement, feldspar.
North Dakota	111,853	38	.30	Petroleum, coal, sand and gravel, natural gas.
Ohio	806,979	13	2.19	Coal, stone, cement, lime.
Oklahoma	1,323,626	6	3.60	Petroleum, natural gas, natural gas liquids, stone.
Oregon	81,466	40	.22	Sand and gravel, stone, cement, nickel.
Pennsylvania	1,401,900	5	3.81	Coal, cement, stone, sand and gravel.
Rhode Island	4,340	49	.01	Sand and gravel, stone, gem stones.
South Carolina	88,361	39	.24	Cement, stone, clays, sand and gravel.
South Dakota	81,139	41	.22	Gold, sand and gravel, cement, stone.
Tennessee	275,690	28	.75	Stone, coal, cement, zinc.
Texas	8,442,494	1	22.95	Petroleum, natural gas, natural gas liquids, cement.
Utah	674,210	15	1.83	Copper, petroleum, coal, gold.
Vermont	29,366	47	.08	Stone, asbestos, sand and gravel, talc.
Virginia	540,595	18	1.47	Coal, stone, sand and gravel, cement.
Washington	114,329	36	.31	Sand and gravel, cement, coal, stone.
West Virginia	1,503,045	4	4.09	Coal, natural gas, stone, cement.
Wisconsin	114,339	35	.31	Sand and gravel, stone, iron ore, cement.
Wyoming	928,105	10	2.52	Petroleum, sodium compounds, uranium, natural gas.
Total	36,788,000	--	100.00	

Table 5.—Value of mineral production per capita and per square mile in 1973, by State

State	Area (square miles)	1970 population (thousands)	Value of mineral production: Total (thousands)	Per square mile: Dollars	Per square mile: Rank	Per capita: Dollars	Per capita: Rank
Alabama	51,609	3,444	$413,056	$8,004	20	$120	21
Alaska	586,412	300	328,789	561	50	1,096	4
Arizona	113,909	1,771	1,304,988	11,456	14	737	7
Arkansas	53,104	1,923	273,705	5,154	31	142	18
California	158,693	19,953	2,041,686	12,866	12	102	25
Colorado	104,247	2,207	532,776	5,111	32	241	14
Connecticut	5,009	3,032	36,804	7,348	25	12	47
Delaware	2,057	548	3,889	1,891	40	7	49
Florida	58,560	6,789	601,100	10,265	16	89	27
Georgia	58,876	4,590	305,479	5,189	30	67	32
Hawaii	6,450	769	35,147	5,449	29	46	36
Idaho	83,557	713	136,081	1,629	43	191	16
Illinois	56,400	11,114	825,608	14,638	8	74	29
Indiana	36,291	5,194	351,405	9,681	18	68	31
Iowa	56,290	2,824	158,800	2,821	36	56	34
Kansas	82,264	2,247	646,299	7,856	22	288	13
Kentucky	40,395	3,219	1,164,762	28,834	5	362	12
Louisiana	48,523	3,641	5,819,610	119,935	1	1,598	2
Maine	33,215	992	33,493	1,008	48	34	39
Maryland	10,577	3,922	131,907	12,471	13	34	40
Massachusetts	8,257	5,689	59,682	7,228	26	10	48
Michigan	58,216	8,875	789,022	13,553	10	89	26
Minnesota	84,068	3,805	852,785	10,144	17	224	15
Mississppi	47,716	2,217	281,738	5,904	28	127	19
Missouri	69,686	4,677	512,634	7,356	24	110	24
Montana	147,138	694	385,285	2,619	38	555	9
Nebraska	77,227	1,483	80,821	1,047	47	54	35
Nevada	110,540	489	201,813	1,826	41	413	11
New Hampshire	9,304	738	14,119	1,518	45	19	45
New Jersey	7,836	7,168	114,016	14,550	9	16	46
New Mexico	121,666	1,016	1,305,644	10,731	15	1,285	3
New York	49,576	18,237	375,866	7,582	23	21	44
North Carolina	52,586	5,082	146,930	2,794	37	29	42
North Dakota	70,665	618	111,853	1,583	44	181	17
Ohio	41,222	10,652	806,979	19,576	6	76	28
Oklahoma	69,919	2,559	1,323,626	18,931	7	517	10
Oregon	96,981	2,091	81,466	840	49	39	37
Pennsylvania	45,333	11,794	1,401,900	30,924	4	119	22
Rhode Island	1,214	947	4,340	3,575	33	5	50
South Carolina	31,055	2,591	88,361	2,845	35	34	38
South Dakota	77,047	666	81,139	1,053	46	122	20
Tennessee	42,244	3,924	275,690	6,526	27	70	30
Texas	267,338	11,197	8,442,494	31,580	3	754	6
Utah	84,916	1,059	674,210	7,940	21	637	8
Vermont	9,609	444	29,366	3,056	34	66	33
Virginia	40,817	4,648	540,595	13,244	11	116	23
Washington	68,192	3,409	114,329	1,677	42	34	41
West Virginia	24,181	1,744	1,503,045	62,158	2	862	5
Wisconsin	56,154	4,418	114,339	2,036	39	26	43
Wyoming	97,914	332	928,105	9,479	19	2,795	1
Total	3,615,055	202,455	36,788,000	10,176	--	182	--

Table 6.—Mineral production[1] in the United States, by State

Mineral	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)	1972 Quantity	1972 Value (thousands)	1973 Quantity	1973 Value (thousands)
ALABAMA								
Cement:[2]								
Masonry thousand short tons	336	$7,601	349	$8,657	407	$11,221	425	$13,074
Portland do	3,018	51,114	2,284	42,281	2,360	48,577	2,396	55,820
Clays do	2,748	8,213	[3] 2,915	[3] 6,913	[3] 2,850	[3] 7,512	[3] 2,934	[3] 8,788
Coal (bituminous) do	20,560	166,308	17,944	146,180	r 20,814	200,430	19,230	211,695
Iron ore (usable) thousand long tons, gross weight	W	W	415	2,773	327	1,912	271	1,408
Lime thousand short tons	749	10,286	761	11,454	739	11,751	881	14,050
Natural gas million cubic feet	627	87	355	54	3,644	1,282	11,271	4,307
Petroleum (crude) thousand 42-gallon barrels	7,263	20,627	7,832	23,496	9,934	30,466	11,677	41,772
Sand and gravel thousand short tons	6,725	8,144	6,674	7,513	6,352	8,530	9,805	13,870
Stone[4] do	19,982	37,166	17,773	34,413	18,485	42,027	20,043	40,117
Value of items that cannot be disclosed: Asphalt (native), bauxite, cement (slag), clays (bentonite, 1971–73), mica (scrap), natural gas liquids, phosphate rock (1970), salt, stone (dimension), talc, and values indicated by symbol W	XX	13,699	XX	7,758	XX	7,533	XX	8,155
Total	XX	323,245	XX	291,492	XX	371,241	XX	413,056
ALASKA								
Antimony ore and concentrate short tons, antimony content	63	109	--	--	--	--	--	--
Barite thousand short tons	134	835	102	1,075	W	W	W	W
Coal (bituminous) do	549	4,059	698	5,710	668	W	694	W
Gem stones	NA	W	NA	W	NA	57	NA	57
Gold (recoverable content of ores, etc.) troy ounces	34,776	1,265	13,012	537	8,639	506	7,107	695
Lead (recoverable content of ores, etc.) short tons	--	--	--	--	--	--	6	2
Natural gas million cubic feet	111,576	27,448	121,618	17,878	125,596	18,463	131,007	19,483
Petroleum (crude) thousand 42-gallon barrels	83,616	251,684	79,494	257,562	72,893	235,444	72,323	261,877
Sand and gravel thousand short tons	25,825	41,092	23,617	32,806	14,187	15,214	14,999	19,913
Silver (recoverable content of ores, etc.) thousand troy ounces	2	4	1	1	([5])	([5])	1	2
Stone thousand short tons	6,470	10,014	2,658	5,066	652	3,012	5,967	12,741
Tin long tons	W	W	17	47	W	W	5	12
Value of items that cannot be disclosed: Mercury, natural gas liquids (1971–73), platinum-group metals, uranium (1971–73), and values indicated by symbol W	XX	1,761	XX	2,141	XX	13,442	XX	14,007
Total	XX	338,271	XX	322,823	XX	286,138	XX	328,789
ARIZONA								
Clays thousand short tons	199	454	[3] 119	[3] 84	[3] 134	[3] 355	[3] 117	[3] 459
Coal (bituminous) do	132	W	1,146	W	W	W	3,247	W
Copper short tons	917,918	1,059,277	820,171	852,978	908,612	930,419	927,271	1,103,453
Gem stones	NA	155	NA	160	NA	168	NA	170
Gold (recoverable content of ores, etc.) troy ounces	109,853	3,998	94,038	3,879	102,996	6,036	102,848	10,060

Gypsum ---thousand short tons	98	358	W	W	W	W	158	669
Helium, high purity ---million cubic feet	62	1,186	W	W	W	W	W	W
Iron ore (usable) ---thousand long tons, gross weight	W	W	16	W	W	W	W	W
Lead (recoverable content of ores, etc.) ---short tons	285	89	859	237	1,763	530	763	248
Lime ---thousand short tons	309	4,523	296	4,474	356	6,024	365	7,019
Molybdenum (content of concentrate) --thousand pounds	15,672	26,700	22,684	39,872	27,216	46,791	37,657	59,372
Natural gas (marketed) ---million cubic feet	1,101	188	868	153	r 442	r 80	125	23
Petroleum (crude) ---thousand 42-gallon barrels	1,784	5,281	1,236	3,918	993	3,226	804	3,103
Pumice ---thousand short tons	824	627	949	625	915	722	853	715
Sand and gravel ---do	17,822	19,804	19,791	24,391	24,842	32,420	27,440	38,503
Silver (recoverable content of ores, etc.) thousand troy ounces	7,330	12,981	6,170	9,538	6,653	11,210	7,199	18,416
Stone ---thousand short tons	3,511	7,094	2,873	5,848	4,638	8,018	4,265	9,469
Zinc (recoverable content of ores, etc.) ---short tons	9,618	2,947	7,761	2,499	10,111	3,589	8,427	3,482
Value of items that cannot be disclosed: Asbestos, cement, clays (fire, 1971–73, bentonite), diatomite (1970–72), feldspar, fluorspar (1971–73), mica (scrap), perlite, pyrites, tungsten, and values indicated by symbol W ---	XX	21,105	XX	32,364	XX	r 41,416	XX	49,827
Total ---	XX	1,166,767	XX	981,020	XX	1,091,004	XX	1,304,988
ARKANSAS								
Barite ---thousand short tons	168	3,721	W	W	W	W	W	W
Bauxite ---thousand long tons, dried equivalent	1,869	26,293	1,781	24,979	1,634	21,010	1,686	23,884
Clays ---thousand short tons	1,014	2,902	[3] 936	[3] 1,499	[3] 885	[3] 990	[3] 1,446	[3] 1,412
Coal (bituminous) ---do	268	2,225	276	2,848	428	4,676	434	5,806
Gem stones ---	NA	25	NA	30	NA	32	NA	50
Lime ---thousand short tons	186	2,680	157	2,313	150	2,456	177	2,742
Natural gas ---million cubic feet	181,351	29,560	172,154	29,426	166,522	28,808	157,529	28,985
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels	643	1,824	517	1,686	261	854	204	861
LP gases ---do	1,205	2,482	1,035	2,650	546	1,420	449	1,688
Petroleum (crude) ---do	18,035	51,760	18,263	56,805	18,519	58,335	18,016	70,618
Sand and gravel ---thousand short tons	13,301	16,036	11,630	15,603	11,574	16,558	12,465	20,625
Stone ---do	15,284	22,786	17,647	28,776	16,317	25,020	16,223	26,209
Value of items that cannot be disclosed: Abrasive stones, bromine, cement, clays (kaolin, 1971–73), gypsum, iron ore (1973), mercury (1970–71), soapstone, tripoli, vanadium, and values indicated by symbol W ---	XX	63,331	XX	79,703	XX	81,020	XX	90,825
Total ---	XX	225,625	XX	246,318	XX	241,179	XX	273,705
CALIFORNIA								
Antimony ore and concentrate short tons, antimony content	4	10	--	--	--	--	--	--
Asbestos ---short tons	78,966	6,332	87,144	7,806	90,967	8,673	105,663	10,886
Barite ---thousand short tons	W	W	W	W	4	34	11	152
Boron minerals ---do	1,041	86,827	1,047	89,856	1,121	95,882	1,225	113,648
Cement ---do	9,306	173,126	9,117	169,921	9,086	182,308	9,395	201,892
Clays ---do	2,824	6,506	[3] 2,822	[3] 7,103	2,706	7,387	2,723	6,853
Copper (recoverable content of ores, etc.) --short tons	2,308	2,663	515	536	598	612	369	440
Gem stones ---	NA	200	NA	205	NA	215	NA	220

See footnotes at end of table.

Table 6.—Mineral production[1] in the United States, by State—Continued

Mineral	1970		1971		1972		1973	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
CALIFORNIA—Continued								
Gold (recoverable content of ores, etc.) __troy ounces__	4,999	$182	2,966	$122	3,974	$233	3,647	$357
Gypsum __thousand short tons__	1,132	3,271	1,352	3,884	1,525	4,965	1,778	5,834
Lead (recoverable content of ores, etc.) __short tons__	1,772	553	2,284	630	1,153	347	44	14
Lime __thousand short tons__	572	9,911	630	10,846	608	13,059	632	13,602
Magnesium compounds from seawater and bitterns (partly estimated) __short tons, MgO equivalent__	73,726	7,489	152,918	16,836	175,654	18,421	184,105	19,233
Mercury __76-pound flasks__	18,593	7,582	13,489	3,944	r 5,835	r 1,274	1,219	349
Natural gas __million cubic feet__	649,117	208,367	612,629	199,717	487,278	179,318	449,369	167,615
Natural gas liquids:								
Natural gasoline and cycle products __thousand 42-gallon barrels__	11,993	38,478	11,045	35,545	8,468	27,664	6,865	23,475
LP gases __do__	7,051	16,006	6,755	16,482	5,847	15,962	5,329	19,824
Peat __thousand short tons__	10	W	12	W	29	620	21	373
Petroleum (crude) __thousand 42-gallon barrels__	372,191	945,365	358,484	975,076	347,022	940,430	336,075	1,045,193
Pumice __thousand short tons__	499	832	699	1,179	731	1,507	768	3,237
Salt __do__	1,656	15,053	1,887	21,142	1,621	14,860	1,507	15,533
Sand and gravel __do__	140,259	174,221	115,468	157,683	117,288	162,619	117,470	176,286
Silver (recoverable content of ores, etc.) __thousand troy ounces__	451	799	444	686	175	296	56	143
Stone __thousand short tons__	46,399	66,950	43,336	86,255	37,213	65,811	43,838	77,175
Talc, soapstone, pyrophyllite __short tons__	184,660	2,545	153,227	2,084	155,155	1,186	179,191	1,501
Zinc (recoverable content of ores, etc.) __do__	3,514	1,077	3,003	967	1,202	427	20	8
Value of items that cannot be disclosed: Bromine, calcium-magnesium chloride, carbon dioxide, cement (masonry 1971–73), coal (lignite, 1970–72), diatomite, feldspar, iron ore, lithium minerals, molybdenum, perlite, phosphate rock (1970), potassium salts, rare-earth metal concentrates, sodium carbonate and sulfate, tungsten concentrate, and values indicated by symbol W	XX	125,337	XX	112,218	XX	107,266	XX	137,843
Total	XX	1,899,682	XX	1,920,723	XX	r 1,851,376	XX	2,041,686
COLORADO								
Clays __thousand short tons__	3 637	3 1,503	625	1,334	747	1,533	794	1,710
Coal (bituminous) __do__	6,025	35,243	5,337	33,813	5,522	35,637	6,233	46,190
Copper (recoverable content of ores, etc.) __short tons__	3,749	4,326	3,938	4,096	3,944	4,039	3,123	3,716
Feldspar __do__	477	3	571	4	W	W	W	W
Gem stones	NA	120	NA	125	NA	131	NA	131
Gold (recoverable content of ores, etc.) __troy ounces__	37,114	1,351	42,031	1,734	61,100	3,580	63,422	6,203
Gypsum __thousand short tons__	W	W	W	W	W	W	151	568
Lead (recoverable content of ores, etc.) __short tons__	21,855	6,827	25,746	7,106	31,346	9,423	28,112	9,159
Lime __thousand short tons__	119	1,613	193	3,039	187	4,070	178	3,371
Mica, sheet __pounds__	--	--	8,300	4	14,280	7	--	--
Natural gas __million cubic feet__	105,804	15,553	108,537	16,932	116,949	19,297	137,725	24,304

Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels	745	1,937	929	2,462	1,245	3,349	1,424	4,295
LP gases do	1,542	2,529	1,653	3,190	1,749	3,673	1,978	6,488
Peat thousand short tons	34	210	28	156	39	210	28	163
Petroleum (crude) thousand 42-gallon barrels	24,723	78,619	27,391	92,855	32,015	109,171	36,590	155,507
Pumice thousand short tons	50	268	62	W	59	W	W	W
Sand and gravel do	22,261	24,190	27,000	30,155	28,318	34,631	33,767	45,493
Silver (recoverable content of ores, etc.) thousand troy ounces	2,933	5,194	3,390	5,241	3,664	6,174	3,942	10,083
Stone thousand short tons	3,552	8,076	3,785	7,933	4,507	9,599	6,357	14,003
Uranium (recoverable content U_3O_8) thousand pounds	2,727	15,832	2,536	15,725	1,877	11,825	1,920	12,480
Zinc (recoverable content of ores, etc.) short tons	56,694	17,370	61,181	19,700	63,801	22,649	58,339	24,106
Value of items that cannot be disclosed: Beryllium concentrate (1970–72), carbon dioxide, cement, fluorspar, iron ore, mica (scrap, 1970–71), molybdenum, perlite, pyrites, salt, tin, tungsten, vanadium and values indicated by symbol W	XX	169,060	XX	147,117	XX	146,843	XX	164,806
Total	XX	389,824	XX	392,721	XX	425,841	XX	532,776
CONNECTICUT								
Clays thousand short tons	171	386	174	322	157	292	162	320
Feldspar short tons	W	W	W	W	W	W	77,206	W
Gem stones	NA	8	NA	15	NA	16	NA	16
Mica scrap thousand short tons	W	W	3	W	2	W	3	W
Sand and gravel do	6,765	9,202	6,921	10,262	6,763	11,270	7,806	12,788
Stone do	8,338	16,915	7,193	15,649	8,719	19,695	9,682	21,305
Value of items that cannot be disclosed: Lime and values indicated by symbol W	XX	1,872	XX	1,713	XX	1,850	XX	2,375
Total	XX	28,383	XX	27,961	XX	33,123	XX	36,804
DELAWARE								
Clays thousand short tons	11	11	14	8	15	9	15	9
Gem stones	NA	1	NA	2	NA	W	NA	W
Sand and gravel thousand short tons	1,565	1,603	2,205	2,231	2,257	2,660	3,408	3,678
Value of items that cannot be disclosed: Other nonmetals and values indicated by symbol W	--	--	--	--	XX	202	XX	202
Total	XX	1,615	XX	2,241	XX	2,871	XX	3,889
FLORIDA								
Cement:								
Masonry thousand short tons	W	W	180	4,877	213	6,901	256	8,706
Portland do	W	W	2,177	48,970	2,425	59,773	2,725	72,666
Clays do	872	12,661	[3] 993	[3] 12,834	[3] 922	[3] 10,336	1,139	13,718
Lime do	167	2,810	159	2,958	180	3,527	187	4,026
Natural gas million cubic feet	--	--	903	270	15,521	4,967	33,857	11,613
Peat thousand short tons	46	304	57	412	45	362	44	384
Petroleum (crude) thousand 42-gallon barrels	2,999	W	5,347	W	16,897	W	32,695	150,070

See footnotes at end of table.

Table 6.—Mineral production [1] in the United States, by State—Continued

Mineral	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)	1972 Quantity	1972 Value (thousands)	1973 Quantity	1973 Value (thousands)
FLORIDA—Continued								
Sand and gravel ....thousand short tons..	12,482	$12,254	23,228	$18,836	r 22,363	r $17,009	20,167	$21,415
Stone [4] ....do....	43,089	61,302	42,816	64,332	53,093	81,621	61,735	103,595
Value of items that cannot be disclosed: Clay (kaolin 1971–72), kyanite, magnesium compounds, natural gas liquids, phosphate rock, rare-earth metal concentrate (1972–73), staurolite, stone (dimension), titanium concentrate, zircon concentrate, and values indicated by symbol W	XX	210,711	XX	190,242	XX	r 242,136	XX	214,907
Total	XX	300,042	XX	343,731	XX	r 426,632	XX	601,100
GEORGIA								
Cement:								
Masonry ....thousand short tons..	W	W	63	1,470	68	1,569	67	2,126
Portland ....do....	W	W	1,214	22,470	1,260	27,286	1,201	28,124
Clays ....do....	5,684	110,149	[3] 5,791	[3] 119,096	[3] 6,227	[3] 132,322	[3] 7,721	[3] 160,419
Feldspar ....short tons..	W	W	W	W	W	W	51,523	W
Iron ore (usable) ....thousand long tons, gross weight..	243	1,467	W	W	W	W	W	W
Peat ....thousand short tons..	W	W	1	13	W	W	(5)	4
Sand and gravel ....do....	3,667	4,437	3,697	5,310	3,816	4,729	4,976	6,781
Stone ....do....	26,635	59,200	30,669	69,897	37,074	82,484	40,841	97,506
Talc ....short tons..	45,900	289	53,000	334	45,842	338	38,000	114
Value of items that cannot be disclosed: Barite, bauxite, fire clay (1971–73), kyanite, mica (scrap), rare-earth metal concentrate, titanium concentrate, zircon concentrate, and values indicated by symbol W	XX	27,683	XX	10,895	XX	r 9,589	XX	10,405
Total	XX	203,225	XX	229,485	XX	r 258,317	XX	305,479
HAWAII								
Cement:								
Masonry ....thousand short tons..	11	366	11	431	13	384	16	537
Portland ....do....	396	9,968	375	10,196	402	10,732	453	13,213
Clays ....do....	2	11	W	W	W	W	W	W
Gem stones	W	W	NA	54	NA	57	NA	W
Lime ....thousand short tons..	9	338	8	228	7	266	6	238
Pumice, pumicite, volcanic ash ....do....	350	933	289	779	379	762	354	611
Sand and gravel ....do....	514	1,679	836	1,967	609	1,893	753	2,012
Stone ....do....	[4] 6,332	[4] 15,538	[4] 6,056	[4] 14,357	[4] 5,005	[4] 13,494	7,180	18,466
Value of items that cannot be disclosed: Salt, stone (dimension, 1970–72), and values indicated by symbol W .	XX	132	XX	95	XX	486	XX	70
Total	XX	28,965	XX	28,107	XX	28,074	XX	35,147

IDAHO								
Antimony ore and concentrate short tons, antimony content	993	W	857	817	345	303	322	406
Clays thousand short tons	[3] 13	[3] 28	W	W	57	415	42	227
Copper (recoverable content of ores, etc.) short tons	3,612	4,168	3,776	3,927	2,942	3,013	3,625	4,314
Gem stones	NA	90	NA	100	NA	105	NA	110
Gold (recoverable content of ores, etc.) troy ounces	3,128	114	3,596	148	2,884	169	2,696	264
Gypsum thousand short tons	--	--	--	--	--	--	W	W
Lead (recoverable content of ores, etc.) short tons	61,211	19,121	66,610	18,384	61,407	18,459	61,744	20,116
Mercury 76-pound flasks	1,038	423	1,057	309	161	35	--	--
Peat thousand short tons	W	W	W	W	--	--	--	--
Pumice do	53	94	W	W	W	W	80	110
Sand and gravel do	12,953	10,022	11,279	11,437	7,696	10,294	8,393	10,246
Silver (recoverable content of ores, etc.) thousand troy ounces	19,115	33,849	19,140	29,590	14,251	24,012	13,620	34,840
Stone thousand short tons	[4] 4,240	[4] 6,368	4,149	6,118	3,094	7,042	2,972	8,096
Tungsten concentrate thousand pounds contained W	W	W	r 24	66	W	W	W	W
Zinc (recoverable content of ores, etc.) short tons	41,052	12,578	45,078	14,515	38,647	13,720	46,107	19,052
Value of items that cannot be disclosed: Cement, clays, (fire clay and kaolin, 1970–71), fluorspar (1971), abrasive garnet, iron ore, lime, perlite, phosphate rock, stone (dimension, 1970), vanadium, and values indicated by symbol W	XX	32.904	XX	26,869	XX	28,639	XX	38,300
Total	XX	119,759	XX	112,280	XX	106,206	XX	136,081
ILLINOIS								
Cement:								
Masonry thousand short tons	71	1,874	73	2,336	80	2,483	88	2,901
Portland do	1,494	25,252	1,425	25,975	1,571	33,124	1,572	36,064
Clays do	[3] 1,676	[3] 3,862	1,788	4,294	[3] 1,716	[3] 3,314	[3] 1,758	[3] 3,613
Coal (bituminous) do	65,119	320,705	58,402	318,878	65,523	402,481	61,572	413,309
Fluorspar short tons	148,208	8,637	138,051	9,883	132,405	9,961	160,305	11,871
Gem stones	NA	W	NA	2	NA	2	NA	2
Lead (recoverable content of ores, etc.) short tons	1,532	479	1,238	342	1,335	401	541	176
Natural gas million cubic feet	4,850	761	498	139	1,194	334	1,638	573
Peat thousand short tons	63	711	72	W	74	935	72	1,037
Petroleum (crude) thousand 42-gallon barrels	43,747	141,994	39,084	135,621	34,874	121,013	30,669	132,490
Sand and gravel thousand short tons	43,926	60,155	45,364	59,397	39,929	61,696	43,649	62,029
Stone do	55,776	86,502	[4] 61,991	[4] 106,084	[4] 56,260	[4] 94,225	66,653	114,068
Zinc (recoverable content of ores, etc.) short tons	16,797	5,146	12,706	4,091	11,378	4,039	5,250	2,169
Value of items that cannot be disclosed: Clay (fuller's earth, 1970, 1972–73), lime, natural gas liquids, silver (1971–73), stone (dimension, 1971–72), tripoli, and values indicated by symbol W	XX	32.619	XX	r 33,828	XX	35.729	XX	45,306
Total	XX	688,697	XX	700,870	XX	769,737	XX	825,608
INDIANA								
Cement thousand short tons	[2] 2,151	[2] 41,810	W	W	W	W	W	W
Clays do	1,335	2,139	[3] 1,324	[3] 2,308	[3] 1,419	[3] 2,465	1,436	2,568

See footnotes at end of table.

Table 6.—Mineral production[1] in the United States, by State—Continued

Mineral	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)	1972 Quantity	1972 Value (thousands)	1973 Quantity	1973 Value (thousands)
INDIANA—Continued								
Coal (bituminous) ----thousand short tons	22,263	$102,371	21,396	$110,796	25,949	$144,688	25,253	$153,136
Natural gas ----million cubic feet	153	36	537	89	355	55	276	38
Peat ----thousand short tons	W	W	50	W	45	478	51	475
Petroleum (crude) ----thousand 42-gallon barrels	7,487	23,958	6,658	22,770	6,130	20,964	5,312	20,823
Sand and gravel ----thousand short tons	23,476	25,796	24,982	29,094	27,978	33,290	27,731	35,015
Stone ----do	25,818	45,215	26,233	48,218	27,511	50,919	[4] 32,288	[4] 57,652
Value of items that cannot be disclosed: Abrasive stone, clay (fire, 1971–72), gypsum, lime, sandstone (1973), and values indicated by symbol W	XX	14,461	XX	68,246	XX	69,749	XX	81,698
Total	XX	255,786	XX	281,521	XX	322,608	XX	351,405
IOWA								
Cement:								
Masonry ----thousand short tons	73	1,758	66	1,719	66	1,916	68	2,351
Portland ----do	2,396	45,432	2,392	47,925	2,458	49,635	2,688	59,574
Clays ----do	1,181	1,823	[3] 1,028	[3] 1,702	1,047	2,643	967	2,028
Coal (bituminous) ----do	987	4,059	989	4,609	851	4,138	601	3,279
Gem stones	W	W	W	W	NA	1	NA	W
Gypsum ----thousand short tons	1,136	4,223	1,154	4,460	1,380	5,714	1,470	6,324
Sand and gravel ----do	21,058	20,642	18,279	20,530	17,107	20,140	19,950	25,541
Stone ----do	25,305	41,119	[4] 25,389	[4] 44,977	27,457	48,642	31,541	56,918
Value of items that cannot be disclosed: Clay (fire, 1971), lime, peat, stone (dimension, 1971), and values indicated by symbol W	XX	1,766	XX	1,899	XX	1,667	XX	2,785
Total	XX	120,822	XX	127,821	XX	134,496	XX	158,800
KANSAS								
Cement:								
Masonry ----thousand short tons	46	1,029	50	1,232	59	1,452	73	2,068
Portland ----do	1,729	28,177	1,731	29,961	1,889	35,432	2,026	42,172
Clays ----do	[3] 713	[3] 946	879	1,151	1,170	1,457	1,169	1,490
Coal (bituminous) ----do	1,627	9,102	1,151	6,579	1,227	7,835	1,086	7,979
Helium:								
Crude ----million cubic feet	2,250	30,600	2,510	30,120	r 2,278	r 27,336	1,539	18,468
High purity ----do	354	8,137	342	7,182	384	8,064	416	8,736
Lead (recoverable content of ores, etc.) ----short tons	80	25	--	--	--	--	--	--
Lime ----thousand short tons	6	W	8	W	9	172	10	199
Natural gas ----million cubic feet	899,955	125,994	885,144	127,267	889,268	127,859	893,118	138,521
Natural gas liquids:								
Natural gasoline ----thousand 42-gallon barrels	6,549	14,617	5,387	12,253	5,505	13,170	5,993	17,685
LP gases ----do	20,814	30,597	23,215	39,001	25,099	43,170	24,463	53,819
Petroleum (crude) ----do	84,853	277,469	78,532	276,433	73,744	259,578	66,227	281,465
Salt[6] ----thousand short tons	1,230	18,206	1,240	18,712	1,369	20,562	1,397	23,460

Sand and gravel ---do---	12,968	12,351	11,862	11,351	11,591	10,920	13,261	12,663
Stone ---do---	15,161	22,406	[4] 14,908	23,697	[4] 14,547	[4] 23,849	[4] 18,334	[4] 33,601
Zinc (recoverable content of ores, etc.) ---short tons---	1,186	364	--	--	--	--	--	--
Value of items that cannot be disclosed: Clays (1970), gypsum, pumice, salt (brine), stone (dimension, 1971–73), and values indicated by symbol W ---	XX	3,969	XX	4,505	XX	3,741	XX	3,973
Total ---	XX	583,989	XX	589,444	XX	r 584,597	XX	646,299
KENTUCKY								
Clays [3] ---thousand short tons---	1,020	1,793	956	1,377	920	1,406	1,083	1,961
Coal (bituminous) ---do---	125,305	711,163	119,389	774,735	121,188	824,691	127,645	986,654
Natural gas ---million cubic feet---	77,892	19,161	72,723	18,253	63,648	15,976	62,396	21,839
Petroleum (crude) ---thousand 42-gallon barrels---	11,575	36,461	10,692	35,925	9,702	32,599	8,687	34,515
Sand and gravel ---thousand short tons---	8,760	10,474	8,202	11,061	8,485	11,967	10,331	14,627
Stone [4] ---do---	29,310	45,208	32,514	52,296	34,279	59,690	38,205	70,912
Zinc (recoverable content of ores, etc.) ---short tons---	4,189	1,283	5,268	1,696	1,780	632	273	113
Value of items that cannot be disclosed: Cement, clay (ball), fluorspar, lime (1971–73), natural gas liquids, and stone (quartzite) ---	XX	21,922	XX	30,542	XX	29.949	XX	34,141
Total ---	XX	847,465	XX	925,885	XX	976,910	XX	1,164,762
LOUISIANA								
Clays ---thousand short tons---	1,080	1,575	1,073	1,606	1,000	1,454	979	1,329
Lime ---do---	1,025	12,811	990	17,625	908	19,614	897	16,801
Natural gas ---million cubic feet---	7,788,276	1,503,137	8,081,907	1,632,545	7,972,678	1,626,426	8,242,423	1,846,303
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels---	56,526	174,632	54,424	173,425	52,842	167,768	47,906	167,037
LP gases ---do---	80,385	138,262	90,271	166,099	98,233	185,660	102,701	253,671
Petroleum (crude) ---do---	906,907	3,061,558	935,243	3,359,710	891,827	3,201,659	831,524	3,327,702
Salt ---thousand short tons---	13,584	64,854	13,352	67,950	13,514	67,464	13,152	66,211
Sand and gravel ---do---	18,155	22,363	19,228	24,492	18,920	26,996	13,748	21,165
Stone [4] ---do---	9,183	11,945	9,688	14,139	9,190	14,836	10,802	21,309
Sulfur (Frasch process) ---thousand long tons---	3,618	89,489	3,646	W	3,765	W	3,329	W
Value of items that cannot be disclosed: Cement, gypsum, stone (miscellaneous), and values indicated by symbol W ---	XX	21,695	XX	94,739	XX	99,666	XX	98,082
Total ---	XX	5,102,321	XX	5,552,330	XX	5,411,543	XX	5,819,610
MAINE								
Clays ---thousand short tons---	[3] 41	[3] 55	[3] 42	[3] 56	40	57	41	74
Copper ---short tons---	2,703	3,120	2,510	2,610	1,220	1,249	1,107	1,317
Gem stones ---	NA	35	NA	40	NA	W	NA	W
Lead ---short tons---	--	--	--	--	85	26	204	66
Peat ---thousand short tons---	W	W	2	W	2	99	5	177
Sand and gravel ---do---	12,971	6,888	8,292	5,881	11,818	7,535	13,583	10,304
Silver ---thousand troy ounces---	63	112	41	64	16	27	W	W
Stone ---thousand short tons---	W	W	1,133	2,913	1,078	2,996	1,212	3,329
Zinc (recoverable content of ore, etc.) ---short tons---	9,114	2,792	5,850	1,884	5,820	2,066	19,640	8,115

See footnotes at end of table.

Table 6.—Mineral production [1] in the United States, by State—Continued

Mineral	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)	1972 Quantity	1972 Value (thousands)	1973 Quantity	1973 Value (thousands)
MAINE—Continued								
Value of items that cannot be disclosed: Beryllium concentrate (1970), cement, clays (1970–71), feldspar (1970), and values indicated by symbol W	XX	$10,778	XX	$8,450	XX	$8,867	XX	$10,111
Total	XX	23,780	XX	21,898	XX	22,922	XX	33,493
MARYLAND								
Clays [3] ---thousand short tons	1,129	1,433	1,027	1,558	1,104	2,121	897	1,973
Coal (bituminous) ---do	1,615	8,083	1,644	10,274	1,640	8,961	1,789	13,644
Gem stones	NA	3	NA	8	NA	8	NA	8
Natural gas ---million cubic feet	813	202	214	43	244	51	298	69
Peat ---thousand short tons	4	47	3	39	3	29	2	29
Sand and gravel ---do	12,951	20,434	12,842	23,201	12,594	26,557	12,845	29,625
Stone ---do	16,015	32,783	15,912	34,770	19,431	41,973	18,585	46,732
Value of items that cannot be disclosed: Cement, selected clays, lime, greensand marl (1970–71), potassium salts (1970), and talc and soapstone	XX	25,231	XX	29,527	XX	35,801	XX	39,827
Total	XX	88,216	XX	99,420	XX	115,501	XX	131,907
MASSACHUSETTS								
Clays ---thousand short tons	284	582	186	377	219	416	217	404
Gem stones	NA	2	NA	5	NA	5	NA	5
Peat ---thousand short tons	W	W	2	32	W	W	2	78
Sand and gravel ---do	17,925	22,244	17,343	23,058	18,883	25,655	18,743	26,910
Stone ---do	8,136	24,349	7,816	23,582	7,990	23,500	8,580	28,738
Value of items that cannot be disclosed: Nonmetals and values indicated by symbol W	XX	3,183	XX	3,145	XX	2,852	XX	3,547
Total	XX	50,360	XX	50,199	XX	52,428	XX	59,682
MICHIGAN								
Cement:								
Masonry ---thousand short tons	213	5,253	239	5,872	250	5,959	247	6,185
Portland ---do	5,605	101,019	6,108	104,665	5,901	111,410	6,242	123,442
Clays ---do	2,480	2,887	2,458	3,366	2,514	3,715	2,151	3,304
Copper (recoverable content of ores, etc.) ---short tons	67,543	77,945	56,005	58,245	67,260	68,874	72,221	85,943
Gem stones	NA	W	NA	8	NA	8	NA	8
Gypsum ---thousand short tons	1,312	5,061	1,433	5,585	1,650	7,267	1,882	8,538
Iron ore (usable) ---thousand long tons, gross weight	13,100	168,958	11,833	159,854	12,692	177,461	12,389	180,194
Lime ---thousand short tons	1,538	21,355	1,444	20,549	1,509	22,753	1,545	26,055
Magnesium compounds from seawater and brine (except for metal) ---short tons, MgO equivalent	411,911	38,050	272,918	27,777	377,675	31,484	455,501	41,790
Natural gas ---million cubic feet	38,851	10,373	25,662	6,776	34,221	10,506	44,579	17,495

Natural gas liquids:								
Natural gasoline ------thousand 42-gallon barrels--	599	1,611	553	1,513	395	1,097	372	1,189
LP gases ----do----	1,176	2,764	975	2,623	833	2,274	691	2,529
Peat ----thousand short tons--	167	1,896	202	2,497	219	2,190	232	2,172
Petroleum (crude) ----thousand 42-gallon barrels--	11,693	36,246	11,893	38,859	12,990	41,556	14,614	59,413
Salt ----thousand short tons--	4,899	49,963	4,458	49,007	4,358	50,761	4,818	53,732
Sand and gravel ----do----	53,092	54,646	56,613	62,898	59,467	65,445	62,407	73,972
Silver (recoverable content of ores, etc.) thousand troy ounces--	892	1,579	670	1,036	785	1,323	850	2,175
Stone ----thousand short tons--	41,687	49,501	40,705	49,240	39,754	50,317	45,886	60,494
Value of items that cannot be disclosed: Bromine, calcium-magnesium chloride, iodine, and potassium salts (1970) ----	XX	41,622	XX	40,266	XX	40,367	XX	40,392
Total ----	XX	670,729	XX	640,636	XX	694,767	XX	789,022
MINNESOTA								
Clays ----thousand short tons--	227	335	223	335	[3] 167	[3] 251	[3] 156	[3] 233
Gem stones ----	W	W	NA	13	NA	14	NA	14
Iron ore (usable) ----thousand long tons, gross weight--	54,791	571,488	49,054	547,607	50,595	601,869	62,614	782,197
Manganiferous ore (5% to 35% Mn) short tons, gross weight--	321,436	W	169,732	W	119,324	W	170,971	W
Peat ----thousand short tons--	14	335	W	W	W	W	W	W
Sand and gravel ----do----	46,851	38,802	44,916	37,645	36,792	33,454	37,935	39,438
Stone ----do----	4,579	12,311	5,838	14,346	5,757	16,318	7,581	20,411
Value of items that cannot be disclosed: Abrasive stones, cement, clays (fire, 1972–73), lime, and values indicated by symbol W ----	XX	9,735	XX	8,830	XX	7,763	XX	10,492
Total ----	XX	633,006	XX	608,776	XX	659,669	XX	852,785
MISSISSIPPI								
Clays ----thousand short tons--	1,553	8,062	2,278	8,501	1,919	7,837	2,075	9,082
Natural gas ----million cubic feet--	126,031	23,190	118,805	24,830	103,989	r 22,670	99,706	22,846
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels--	544	1,465	W	W	W	W	W	W
LP gases ----do----	428	964	W	W	W	W	W	W
Petroleum (crude) ----do----	65,119	194,706	64,066	201,808	61,100	192,465	56,102	213,747
Sand and gravel ----thousand short tons--	10,859	11,950	11,289	13,526	13,419	16,133	14,251	17,383
Stone ----do----	W	W	726	709	1,135	1,199	[4] 760	[4] 809
Value of items that cannot be disclosed: Cement, lime, magnesium compounds, limestone (1973), and values indicated by symbol W ----	XX	9,636	XX	12,790	XX	14,970	XX	17,871
Total ----	XX	249,973	XX	262,164	XX	r 255,274	XX	281,738
MISSOURI								
Barite ----thousand short tons--	230	3,555	232	3,606	213	3,637	196	3,395
Cement:								
Masonry ----do----	56	1,234	73	1,629	80	1,859	84	2,400
Portland ----do----	3,990	64,261	4,515	77,568	4,277	80,898	4,582	99,858

See footnotes at end of table.

Table 6.—Mineral production[1] in the United States, by State—Continued

Mineral	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)	1972 Quantity	1972 Value (thousands)	1973 Quantity	1973 Value (thousands)
MISSOURI—Continued								
Clays ---thousand short tons--	[3] 2,128	[3] $6,480	[3] 2,354	[3] $7,454	[3] 2,571	[3] $9,096	2,551	$11,626
Coal (bituminous) ---do---	4,447	19,526	4,036	19,670	4,551	23,667	4,658	24,999
Copper (recoverable content of ores, etc.) --short tons--	12,134	14,003	8,445	8,783	11,509	11,785	10,273	12,224
Iron ore (usable) --thousand long tons, gross weight--	2,612	38,100	2,727	W	2,695	W	2,630	W
Lead (recoverable content of ores, etc.) ---short tons--	421,764	131,751	429,634	118,579	489,397	147,113	487,143	158,711
Lime ---thousand short tons--	W	W	W	W	W	W	1,626	23,534
Natural gas ---million cubic feet--	87	21	22	5	9	2	33	8
Petroleum (crude) ---thousand 42-gallon barrels--	66	W	66	W	60	W	60	W
Phosphate rock ---thousand short tons--	--	--	--	--	--	--	42	W
Sand and gravel ---do---	12,446	15,379	10,327	15,109	10,082	14,806	10,879	16,950
Silver (recoverable content of ores, etc.) thousand troy ounces--	1,817	3,218	1,661	2,568	1,972	3,322	2,058	5,264
Stone ---thousand short tons--	39,726	[4] 57,285	41,099	[4] 64,772	42,473	[4] 63,219	49,304	79,921
Zinc (recoverable content of ores, etc.) ---short tons--	50,721	15,540	48,215	15,525	61,923	21,983	82,350	34,027
Value of items that cannot be disclosed: Asphalt (native), clays (selected, 1970–72), and values indicated by symbol W ---	XX	22,643	XX	64,821	XX	70,430	XX	39,717
Total ---	XX	392,996	XX	400,089	XX	451,817	XX	512,634
MONTANA								
Antimony ---short tons--	W	W	135	81	W	W	W	W
Clays[3] ---thousand short tons--	41	71	264	1,712	304	1,590	219	1,298
Coal (bituminous and lignite) ---do---	3,447	6,394	7,064	12,817	8,221	16,690	10,725	30,238
Copper (recoverable content of ores, etc.) --short tons--	120,412	138,955	88,581	92,125	123,110	126,064	132,466	157,634
Gem stones ---	NA	109	NA	114	NA	120	NA	150
Gold (recoverable content of ores, etc.) ---troy ounces--	22,456	817	15,613	644	23,725	1,390	27,806	2,720
Iron ore (usable) ---thousand long tons, gross weight--	14	W	14	W	9	W	13	W
Lead (recoverable content of ores, etc.) ---short tons--	996	311	615	169	287	86	176	57
Lime ---thousand short tons--	208	W	199	2,416	242	3,003	210	3,028
Manganese ore and concentrate (35% or more Mn) short tons, gross weight--	512	W	142	W	578	W	239	W
Natural gas ---million cubic feet--	42,705	4,399	32,720	3,959	33,474	4,117	57,175	13,240
Peat ---thousand short tons--	W	W	W	W	1	W	1	W
Petroleum (crude) ---thousand 42-gallon barrels--	37,879	105,403	34,599	104,128	33,904	103,924	34,620	115,423
Sand and gravel ---thousand short tons--	19,275	20,249	15,781	25,207	10,116	17,149	11,694	13,819
Silver (recoverable content of ores, etc.) thousand troy ounces--	4,304	7,622	2,748	4,248	3,325	5,603	4,350	11,127
Stone ---thousand short tons--	[4] 6,501	[4] 6,896	W	W	4,074	5,627	5,054	9,559
Tungsten ore and concentrate thousand pounds contained W--	[r] 8	23	W	W	W	W	W	W
Zinc (recoverable content of ores, etc.) ---short tons--	1,457	446	361	116	12	4	73	30
Value of items that cannot be disclosed: Cement, clays (selected), fluorspar, gypsum, natural gas liquids, phosphate rock, stone (1970–71), talc, vermiculite and values indicated by symbol W ---	XX	21,321	XX	37,337	XX	22,309	XX	26,962
Total ---	XX	313,016	XX	285,073	XX	307,676	XX	385,285

NEBRASKA								
Clays ----thousand short tons--	90	147	69	82	115	143	158	286
Gem stones ----	NA	5	NA	10	NA	11	NA	11
Lime ----thousand short tons--	27	W	29	W	34	685	31	651
Liquefied petroleum gases --thousand 42-gallon barrels--	365	858	W	W	W	W	W	W
Natural gas (marketed) ----million cubic feet--	5,991	1,024	3,496	612	3,478	619	3,836	698
Petroleum (crude) ----thousand 42-gallon barrels--	11,451	35,384	10,062	34,010	8,705	29,423	7,240	28,035
Sand and gravel ----thousand short tons--	12,232	12,974	13,224	13,626	13,720	15,063	15,906	18,366
Stone ----do----	4,265	7,378	4,174	7,892	4,251	7,645	5,368	10,958
Value of items that cannot be disclosed: Cement, natural gasoline, pumice (1970–72), and values indicated by symbol W ----	XX	14,887	XX	17,847	XX	20,086	XX	21,816
Total ----	XX	72,657	XX	74,079	XX	73,675	XX	80,821
NEVADA								
Barite ----thousand short tons--	192	1,455	192	1,490	317	2,659	549	4,691
Clays ----do----	W	W	W	W	40	183	36	176
Copper (recoverable content of ores, etc.) --short tons--	106,688	123,118	96,928	100,806	101,119	103,545	93,702	111,505
Gem stones ----	NA	100	NA	105	NA	110	NA	142
Gold (recoverable content of ores, etc.) --troy ounces--	480,144	17,472	374,878	15,464	419,748	24,597	260,437	25,473
Gypsum ----thousand short tons--	451	1,457	695	2,372	860	2,871	1,154	3,662
Iron ore (usable) ----thousand long tons, gross weight--	575	W	W	W	W	W	119	W
Lead (recoverable content of ores, etc.) ----short tons--	364	114	111	30	(5)	(5)	--	--
Mercury ----76-pound flasks--	4,909	2,001	1,589	465	810	177	698	200
Perlite ----short tons--	8,470	73	9,600	114	W	W	W	W
Petroleum (crude) ----thousand 42-gallon barrels--	149	W	113	W	100	W	96	W
Pumice ----thousand short tons--	80	191	112	232	W	W	W	W
Sand and gravel ----do----	8,574	9,819	9,379	12,225	10,081	12,636	12,448	14,614
Silver (recoverable content of ores, etc.) thousand troy ounces--	718	1,271	601	930	595	1,003	624	1,595
Stone ----thousand short tons--	1,860	2,722	2,531	3,800	3,329	5,926	3,595	5,429
Tungsten ore and concentrate thousand pounds contained W--	r 115	306	r 31	88	r 157	W	150	377
Zinc (recoverable content of ores, etc.) ----short tons--	127	39	71	23	--	--	--	--
Value of items that cannot be disclosed: Antimony, brucite (1970–71), cement, diatomite, fluorspar, lime, lithium minerals, magnesite, molybdenum, pyrites (1970–71), salt, talc (1970, 1972–73), and values indicated by symbol W ----	XX	26,207	XX	26,630	XX	27,995	XX	33,949
Total ----	XX	186,345	XX	164,774	XX	181,702	XX	201,813
NEW HAMPSHIRE								
Clays ----thousand short tons--	40	32	37	34	51	70	43	64
Gem stones ----	W	W	NA	40	NA	42	NA	42
Sand and gravel ----thousand short tons--	6,529	4,753	8,404	6,777	6,020	6,256	7,795	8,597
Stone ----do----	W	845	429	3,433	528	3,743	1,836	5,416
Value of items that cannot be disclosed: Mica (scrap, 1970) and values indicated by symbol W ----	XX	3,100	--	--	--	--	--	--
Total ----	XX	8,730	XX	10,284	XX	10,111	XX	14,119

See footnotes at end of table.

Table 6.—Mineral production[1] in the United States, by State—Continued

Mineral	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)	1972 Quantity	1972 Value (thousands)	1973 Quantity	1973 Value (thousands)
NEW JERSEY								
Clays ----thousand short tons--	262	$990	201	$864	212	$856	183	$666
Gem stones ----	NA	10	NA	15	NA	16	NA	16
Peat ----thousand short tons--	45	557	46	526	W	W	44	514
Sand and gravel ----do----	16,732	31,571	18,511	38,279	17,679	38,020	19,040	43,098
Stone[4] ----do----	15,160	40,567	13,469	36,057	r 15,223	r 42,044	15,902	45,585
Zinc (recoverable content of ores, etc.) ----short tons--	28,683	8,788	29,977	9,653	38,096	13,524	33,027	13,647
Value of items that cannot be disclosed: Lime, magnesium compounds, manganiferous residuum, greensand marl, stone (dimension), titanium concentrate, and values indicated by symbol W ----	XX	6,798	XX	8,178	XX	8,261	XX	10,490
Total ----	XX	89,281	XX	93,572	XX	r 102,721	XX	114,016
NEW MEXICO								
Clays ----thousand short tons--	67	91	[3] 76	[3] 114	[3] 65	[3] 108	[3] 88	[3] 169
Coal (bituminous) ----do----	7,361	21,249	8,175	26,657	8,248	29,794	9,069	31,862
Copper (recoverable content of ores, etc.) --short tons--	166,278	191,885	157,419	163,716	168,034	172,067	204,742	243,643
Gem stones ----	NA	60	NA	65	NA	68	NA	70
Gold (recoverable content of ores, etc.) ----troy ounces--	8,719	317	10,681	441	14,897	873	13,864	1,356
Gypsum ----thousand short tons--	W	W	W	W	W	W	255	1,220
Helium:								
Crude ----million cubic feet--	1	18	--	--	--	--	--	--
High purity ----do----	(5)	6	W	W	--	--	--	--
Iron ore (usable) ----thousand long tons, gross weight--	W	W	W	W	W	W	5	114
Lead (recoverable content of ores, etc.) ----short tons--	3,550	1,109	2,971	820	3,582	1,077	2,556	833
Lime ----thousand short tons--	37	W	35	W	28	W	44	793
Manganese ore (35% or more Mn) short tons, gross weight--	4,225	W	--	--	--	--	--	--
Manganiferous ore (5% to 35% Mn) ----do----	46,166	W	28,490	W	27,837	W	32,084	W
Mica, scrap ----thousand short tons--	W	W	W	W	14	W	10	82
Natural gas ----million cubic feet--	1,138,980	162,874	1,167,577	175,137	1,216,061	225,420	1,218,749	287,889
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels--	9,606	25,548	9,952	28,465	10,338	29,970	9,848	32,449
LP gases ----do----	25,999	37,179	27,082	43,331	27,859	45,689	29,652	74,427
Peat ----thousand short tons--	(5)	7	1	W	2	46	3	50
Perlite ----do----	382	4,321	386	4,559	476	5,698	478	5,024
Petroleum (crude) ----thousand 42-gallon barrels--	128,184	410,320	118,412	402,602	110,525	376,778	100,986	414,041
Potassium salts --thousand short tons, K_2O equivalent--	2,390	85,877	2,291	86,689	2,296	91,115	2,168	91,996
Pumice ----thousand short tons--	203	442	287	601	311	809	339	1,001
Salt ----do----	W	W	146	1,130	W	W	W	W
Sand and gravel ----do----	10,666	10,516	8,869	7,975	7,600	8,553	10,641	15,753
Silver (recoverable content of ores, etc.) thousand troy ounces--	782	1,385	782	1,210	1,017	1,713	1,111	2,843
Stone ----thousand short tons--	[4] 3,110	[4] 4,030	[4] 2,913	[4] 5,337	2,768	5,499	2,830	5,894

Tin ---long tons--	--	--	--	--	--	--	W	W
Uranium (recoverable content U_3O_8) --thousand pounds--	11,574	69,970	10,567	65,517	10,808	68,091	9,140	59,410
Zinc (recoverable content of ores, etc.) ----short tons--	16,601	5,086	13,959	4,495	12,735	4,521	12,327	5,094
Value of items that cannot be disclosed: Carbon dioxide, cement, clay (fire), fluorspar (1970–72), molybdenum, stone (1970–71), vanadium, and values indicated by symbol W ---	XX	28,068	XX	27,424	XX	29,403	XX	29,631
Total ---	XX	1,060,358	XX	1,046,285	XX	1,097,292	XX	1,305,644
NEW YORK								
Clays ---thousand short tons--	1,707	1,897	[3] 1,588	[3] 1,742	[3] 1,601	[3] 1,919	[3] 1,799	[3] 2,146
Emery ---short tons--	W	W	1,585	W	2,883	W	2,883	W
Gem stones ---	NA	10	NA	15	NA	16	NA	16
Gypsum ---thousand short tons--	425	2,737	415	2,376	486	3,079	525	3,369
Lead (recoverable content of ores, etc.) ----short tons--	1,280	400	877	242	1,089	327	2,304	751
Mercury ---76-pound flasks--	28	11	W	W	W	W	--	--
Natural gas ---million cubic feet--	3,358	1,017	2,202	661	3,679	1,199	4,539	1,590
Peat ---thousand short tons--	15	145	15	196	15	200	11	166
Petroleum (crude) ---thousand 42-gallon barrels--	1,194	5,397	1,126	5,292	1,018	4,897	967	5,412
Salt ---thousand short tons--	5,990	47,254	5,303	43,601	5,604	43,866	5,202	42,364
Sand and gravel ---do----	35,537	38,839	23,221	28,328	26,722	36,952	29,544	41,396
Silver (recoverable content of ores, etc.) thousand troy ounces--	24	42	18	28	25	42	54	139
Stone ---thousand short tons--	37,616	68,118	37,778	73,418	38,138	77,825	44,393	94,698
Zinc (recoverable content of ores, etc.) ----short tons--	58,577	17,947	63,420	20,421	60,749	21,566	81,455	33,657
Value of items that cannot be disclosed: Cement, clay (ball, 1971–73), garnet (abrasive), iron ore, lime, talc, titanium concentrate, wollastonite, and values indicated by symbol W ---	XX	115,750	XX	122,963	XX	r 128,566	XX	150,167
Total ---	XX	299,564	XX	299,283	XX	r 320,454	XX	375,866
NORTH CAROLINA								
Clays [3] ---thousand short tons--	3,318	3,102	3,503	3,802	3,862	4,473	4,109	5,057
Feldspar ---short tons--	386,608	5,173	393,811	4,681	439,838	6,030	523,595	8,820
Gem stones ---	NA	20	NA	30	NA	32	NA	40
Mica:								
Scrap ---thousand short tons--	64	1,457	67	1,770	91	2,942	106	4,423
Sheet ---pounds--	--	--	8,705	3	--	--	--	--
Sand and gravel ---thousand short tons--	12,772	13,277	14,240	14,690	r 12,823	r 13,812	15,897	19,327
Stone ---do----	30,363	54,121	30,917	58,026	32,297	62,741	38,782	80,065
Talc and pyrophyllite ---short tons--	92,639	544	85,289	522	89,334	594	95,833	1,094
Value of items that cannot be disclosed: Asbestos, cement, clay (kaolin), copper (1971), gold (1971), iron ore, lead (1971), lithium minerals, olivine, phosphate rock, silver (1971), tungsten (1970–71), zinc (1971) ---	XX	20,671	XX	25,996	XX	24,896	XX	28,104
Total ---	XX	98,365	XX	109,520	XX	r 115,520	XX	146,930
NORTH DAKOTA								
Coal (lignite) ---thousand short tons--	5,639	11,009	6,075	11,580	6,632	13,416	6,906	14,328
Gem stones ---	NA	1	NA	2	NA	2	NA	2

See footnotes at end of table.

Table 6.—Mineral production[1] in the United States, by State—Continued

Mineral	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)	1972 Quantity	1972 Value (thousands)	1973 Quantity	1973 Value (thousands)
NORTH DAKOTA—Continued								
Natural gas ____million cubic feet__	34,889	$5,722	33,864	$5,655	32,472	$5,455	27,703	$5,457
Natural gas liquids:								
Natural gasoline ____thousand 42-gallon barrels__	504	1,376	W	W	W	W	W	W
LP gases ____do____	1,840	2,944	W	W	W	W	W	W
Petroleum (crude) ____do____	21,998	67,107	21,653	70,805	20,624	67,647	20,235	78,916
Sand and gravel ____thousand short tons__	8,090	6,336	8,196	6,210	6,681	5,757	6,011	6,021
Stone ____do____	103	126	W	W	--	--	W	W
Value of items that cannot be disclosed: Clays, lime, peat (1970–71), pumice (1972), salt, and values indicated by symbol W ____	XX	1,426	XX	5,649	XX	5,809	XX	7,129
Total ____	XX	96,047	XX	99,901	XX	98,086	XX	111,853
OHIO								
Cement:								
Masonry ____thousand short tons__	121	3,116	142	3,811	161	4,684	176	5,641
Portland ____do____	2,209	39,997	2,897	54,338	2,968	57,953	3,456	73,362
Clays ____do____	3,920	10,100	3,973	11,380	4,125	11,273	4,732	12,456
Coal (bituminous) ____do____	55,351	262,390	51,431	269,601	50,967	303,819	45,783	338,792
Gem stones ____	NA	3	NA	8	NA	8	NA	8
Lime ____thousand short tons__	3,951	61,197	4,007	65,258	4,413	75,569	4,389	77,028
Natural gas ____million cubic feet__	52,113	14,123	79,903	27,007	89,995	35,271	93,610	39,786
Peat ____thousand short tons__	6	95	6	84	4	67	4	64
Petroleum (crude) ____thousand 42-gallon barrels__	9,864	32,914	8,286	29,801	9,358	35,179	8,796	44,690
Salt ____thousand short tons__	5,329	47,498	5,709	46,651	6,147	47,710	4,657	41,643
Sand and gravel ____do____	42,069	57,506	40,797	54,044	43,506	59,932	48,987	69,982
Stone ____do____	47,244	81,506	46,891	88,372	48,498	90,821	[4] 55,107	[4] 98,009
Value of items that cannot be disclosed: Abrasive stone, gypsum, and stone (dimension, 1973) ____	XX	1,721	XX	1,796	XX	2,462	XX	5,518
Total ____	XX	612,166	XX	652,151	XX	724,748	XX	806,979
OKLAHOMA								
Clays[3] ____thousand short tons__	769	1,120	845	1,255	938	1,398	1,298	1,871
Coal (bituminous) ____do____	2,427	15,211	2,234	15,004	2,624	19,112	2,183	16,779
Gypsum ____do____	874	2,616	1,022	3,073	1,196	3,888	1,429	5,796
Helium:								
High purity ____million cubic feet__	149	5,214	123	4,305	r 176	r 6,160	181	6,335
Crude ____do____	245	2,940	270	3,240	163	1,956	115	1,380
Lead (recoverable content of ores, etc.) ____short tons__	797	249	--	--	--	--	--	--
Natural gas ____million cubic feet__	1,594,943	248,811	1,684,260	273,945	1,806,887	294,523	1,770,980	334,110
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels__	14,813	39,933	14,197	40,856	14,559	42,709	14,674	49,070
LP gases ____do____	28,029	52,975	27,540	56,732	27,148	57,011	29,044	95,264

Petroleum (crude) ----do----	223,574	712,419	213,313	725,611	207,633	709,033	191,204	723,273
Pumice ----thousand short tons--	--	--	W	W	W	W	1	W
Salt ----do----	13	78	W	W	W	W	5	36
Sand and gravel ----do----	5,675	7,258	5,713	8,259	7,901	11,138	12,154	14,941
Stone ----do----	18,177	23,701	19,449	27,125	19,448	26,574	22,316	34,999
Zinc (recoverable content of ores, etc.) ----short tons--	2,650	812	(5)	(5)	W	W	--	--
Value of items that cannot be disclosed: Cement, clay (bentonite), copper, lime, silver, tripoli, and values indicated by symbol W ----	XX	24,935	XX	30,111	XX	37,296	XX	39,772
Total ----	XX	1,138,272	XX	1,189,516	XX	r 1,210,798	XX	1,323,626
OREGON								
Clays ----thousand short tons--	[3] 134	[3] 180	157	255	151	238	168	291
Copper ----short tons--	W	W	3	3	W	W	W	W
Diatomite ----do----	500	5	70	1	W	W	W	W
Gem stones ----	NA	750	NA	755	NA	793	NA	700
Gold (recoverable content of ores, etc.) --troy ounces--	256	9	244	10	W	W	W	W
Lead ----short tons--	(5)	(5)	--	--	--	--	--	--
Lime ----thousand short tons--	96	1,777	106	1,989	96	2,129	106	2,552
Mercury ----76-pound flasks--	274	112	W	W	--	--	W	W
Nickel (content of ore and concentrate) ----short tons--	15,933	W	17,036	W	16,864	W	18,272	W
Pumice ----thousand short tons--	939	1,221	943	1,389	W	W	1,006	1,902
Sand and gravel ----do----	17,532	25,978	20,230	28,707	24,489	34,981	22,802	32,751
Silver (recoverable content of ores, etc.) thousand troy ounces--	4	6	4	6	2	4	1	3
Stone ----thousand short tons--	13,439	20,948	13,794	26,708	10,915	18,380	13,411	21,843
Value of items that cannot be disclosed: Bauxite (1970), cement, clay (fire, 1970), talc and soapstone, tungsten (1971–72), and values indicated by symbol W ----	XX	17,095	XX	18,212	XX	19,991	XX	21,424
Total ----	XX	68,081	XX	78,035	XX	76,516	XX	81,466
PENNSYLVANIA								
Cement:								
Masonry ----thousand short tons--	527	8,324	559	11,247	451	12,401	490	14,443
Portland ----do----	7,691	121,100	7,850	140,460	8,214	156,008	8,563	171,653
Clays ----do----	[3] 2,665	[3] 15,845	[3] 2,325	[3] 8,940	2,682	15,829	[3] 2,975	[3] 16,664
Coal:								
Anthracite ----do----	9,729	105,341	8,727	103,469	7,106	85,251	6,830	90,260
Bituminous ----do----	80,491	585,057	73,835	620,196	75,939	694,267	76,403	786,792
Copper (recoverable content of ores, etc.) --short tons--	2,539	2,930	3,349	3,483	2,611	2,673	1,845	2,195
Gem stones ----	NA	4	NA	9	NA	9	NA	9
Lime ----thousand short tons--	1,887	29,279	1,760	30,008	1,891	33,802	2,260	40,949
Mica, scrap ----do----	1	60	W	W	W	W	--	--
Natural gas ----million cubic feet--	76,841	21,439	76,451	20,770	73,958	22,389	78,514	32,976
Natural gas liquids:								
Natural gasoline ----thousand 42-gallon barrels--	19	50	W	W	W	W	W	W
LP gases ----do----	34	87	W	W	W	W	W	W
Peat ----thousand short tons--	44	517	38	461	22	320	28	411
Petroleum (crude) ----thousand 42-gallon barrels--	4,093	18,500	3,798	17,699	3,441	16,414	3,282	18,440
Sand and gravel ----thousand short tons--	18,504	33,915	19,668	36,162	18,757	36,804	20,576	42,830
Stone ----do----	66,119	120,187	64,467	118,469	67,307	124,340	78,564	150,346

See footnotes at end of table.

Table 6.—Mineral production[1] in the United States, by State—Continued

Mineral	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)	1972 Quantity	1972 Value (thousands)	1973 Quantity	1973 Value (thousands)
PENNSYLVANIA—Continued								
Zinc (recoverable content of ores, etc.) ----short tons--	29,554	$9,055	27,438	$8,835	18,344	$6,512	18,857	$7,792
Value of items that cannot be disclosed: Clay (kaolin 1970–71, 1973), cobalt (1970–71), gold (1970–71), iron ore, pyrites (1970–71), pyrophyllite (1970), silver (1970–71), tripoli, and values indicated by symbol W -------	XX	24,053	XX	28,899	XX	24,466	XX	26,140
Total ----	XX	1,095,743	XX	1,149,107	XX	1,231,485	XX	1,401,900
RHODE ISLAND								
Sand and gravel ----thousand short tons--	2,387	2,913	2,252	3,052	2,079	3,336	2,429	3,095
Stone ----do----	W	W	3	422	[4] 329	[4] 23	W	W
Value of items that cannot be disclosed: Other nonmetals and values indicated by symbol W ----	XX	1,473	XX	825	XX	932	XX	1,245
Total ----	XX	4,386	XX	4,299	XX	4,291	XX	4,340
SOUTH CAROLINA								
Clays ----thousand short tons--	1,974	9,878	[3] 2,049	[3] 10,201	2,221	11,268	[3] 2,250	[3] 12,877
Gem stones ----	--	--	--	--	--	--	NA	5
Peat ----thousand short tons--	W	W	W	W	W	W	14	W
Sand and gravel ----do----	5,864	7,766	6,438	9,119	7,916	12,121	8,179	12,628
Stone ----do----	9,710	[4] 14,734	11,047	17,852	12,482	21,819	14,985	24,280
Value of items that cannot be disclosed: Cement, clays (selected, 1971, 1973), feldspar (1970–72), mica (scrap), certain stone (1970), vermiculite, and values indicated by symbol W ----	XX	23,987	XX	29,716	XX	37,105	XX	38,571
Total ----	XX	56,365	XX	66,888	XX	82,313	XX	88,361
SOUTH DAKOTA								
Clays ----thousand short tons--	165	946	[3] 150	[3] 128	[3] 185	[3] 156	[3] 201	[3] 181
Feldspar ----short tons--	19,276	114	24,640	539	r 25,000	r 400	W	W
Gem stones ----	NA	35	NA	40	NA	42	NA	42
Gold (recoverable content of ores, etc.) --troy ounces--	578,716	21,059	513,427	21,179	407,430	23,875	375,575	34,974
Gypsum ----thousand short tons--	15	61	21	83	24	43	W	W
Lead (recoverable content of ores, etc.) ----short tons--	3	1	--	--	--	--	--	--
Lime ----thousand short tons--	W	W	W	W	W	W	63	1,206
Mica (scrap) ----do----	(5)	34	W	W	W	W	--	--
Petroleum (crude) ----thousand 42-gallon barrels--	160	374	233	604	219	574	275	988
Sand and gravel ----thousand short tons--	16,556	16,656	16,727	18,392	12,748	14,793	13,963	16,587
Silver (recoverable content of ores, etc.) thousand troy ounces--	120	212	107	165	100	168	72	184
Stone ----thousand short tons--	1,979	13,375	2,199	8,874	2,665	10,864	2,745	11,607
Zinc (recoverable content of ores, etc.) ----short tons--	1	(5)	--	--	--	--	--	--

Value of items that cannot be disclosed: Beryllium concentrate (1970–72), cement, clays (bentonite 1971–73), uranium (1970–72), vanadium (1970, 1972), and values indicated by symbol W	XX	8,709	XX	12,984	XX	14,535	XX	15,370
Total	XX	61,576	XX	62,988	XX	r 65,450	XX	81,139
TENNESSEE								
Barite ----- thousand short tons	19	286	21	342	W	W	W	W
Cement:								
Masonry ----- do	136	2,749	159	3,649	176	4,104	201	7,908
Portland ----- do	1,669	29,832	1,713	33,733	1,695	37,176	1,711	42,402
Clays [3] ----- do	1,401	7,123	1,537	6,595	1,718	7,719	1,719	9,083
Coal (bituminous) ----- do	8,237	40,372	9,271	59,368	11,260	81,386	8,219	66,827
Copper (recoverable content of ores, etc.) ----- short tons	15,535	17,928	13,916	14,473	11,310	11,581	8,500	10,115
Gold (recoverable content of ores, etc.) ----- troy ounces	124	5	192	8	176	10	68	7
Natural gas ----- million cubic feet	64	13	89	20	25	8	20	6
Petroleum (crude) ----- thousand 42-gallon barrels	309	W	398	W	198	W	201	W
Phosphate rock ----- thousand short tons	3,073	15,005	2,571	12,151	2,154	10,732	2,512	12,799
Sand and gravel ----- do	6,715	10,639	8,018	11,845	10,839	15,328	12,010	20,145
Silver (recoverable content of ores, etc.) thousand troy ounces	95	168	131	203	83	141	73	187
Stone ----- thousand short tons	35,374	50,013	32,369	48,665	35,942	55,512	42,742	71,116
Zinc (recoverable content of ores, etc.) ----- short tons	118,260	36,233	119,295	38,413	101,722	36,111	64,172	26,516
Value of items that cannot be disclosed: Clay (fuller's earth), lime, pyrites, and values indicated by symbol W	XX	10.099	XX	10.197	XX	10,006	XX	8,579
Total	XX	220,465	XX	239,662	XX	269,814	XX	275,690
TEXAS								
Cement:								
Masonry ----- thousand short tons	141	3,769	169	4,514	217	5,812	234	6,606
Portland ----- do	6,386	122,960	7,198	140,206	7,813	171,642	8,320	189,368
Clays ----- do	4,148	9,587	4,615	10,432	5,175	11,554	5,667	13,115
Coal (lignite) ----- do	W	W	W	W	4,045	W	6,944	W
Gem stones -----	NA	150	NA	155	NA	163	NA	163
Gypsum ----- thousand short tons	1,220	4,252	1,303	4,806	1,542	5,284	1,616	6,469
Helium:								
Crude ----- million cubic feet	1,157	13,262	1,208	14,496	1,026	12,312	904	10,848
High purity ----- do	82	2,862	50	1,750	--	--	--	--
Lime ----- thousand short tons	1,673	24,427	1,612	24,583	1,631	22,181	1,677	26,887
Natural gas ----- million cubic feet	8,357,716	1,203,511	8,550,705	1,376,664	8,657,840	1,419,886	8,513,850	1,735,221
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels	97,511	284,871	96,286	299,981	92,437	294,163	92,743	347,393
LP gases ----- do	204,177	334,850	210,435	380,887	226,624	428,319	221,686	589,685
Perlite ----- short tons	--	--	--	--	2,391	24	602	W
Petroleum (crude) ----- thousand 42-gallon barrels	1,249,607	4,104,005	1,222,926	4,261,775	1,301,685	4,536,077	1,294,671	5,157,623
Pumice ----- thousand short tons	W	W	4	4	W	W	--	--
Salt ----- do	10,184	45,000	9,217	40,838	9,744	36,544	10,354	45,350
Sand and gravel ----- do	31,438	46,362	32,788	51,814	35,151	56,328	38,546	60,706
Stone ----- do	45,557	64,422	41,168	[4] 62,144	49,314	[4] 66,573	62,574	91,379
Sulfur (Frasch process) ----- thousand long tons	2,801	62,290	3,092	W	3,847	W	4,109	W

See footnotes at end of table.

Table 6.—Mineral production[1] in the United States, by State—Continued

Mineral	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)	1972 Quantity	1972 Value (thousands)	1973 Quantity	1973 Value (thousands)
TEXAS—Continued								
Talc and soapstone ..... short tons	171,420	$878	193,830	$1,024	221,022	$1,262	232,514	$1,246
Value of items that cannot be disclosed: Asphalt (native), fluorspar (1972–73), graphite, iron ore, magnesium chloride (for metal), magnesium compounds (except for metal), mercury, sodium sulfate, stone (dimension, 1971–72), uranium, and values indicated by symbol W	XX	74,541	XX	132,210	XX	143,427	XX	160,435
Total	XX	6,401,999	XX	6,808,283	XX	7,211,551	XX	8,442,494
UTAH								
Carbon dioxide, natural ..... thousand cubic feet	60,754	4	55,178	4	61,103	4	80,490	6
Clays ..... thousand short tons	189	1,237	198	1,064	[3] 266	[3] 790	[3] 243	[3] 771
Coal (bituminous) ..... do	4,733	34,472	4,626	34,082	4.802	42,868	5,500	61,566
Copper (recoverable content of ores, etc.) ..... short tons	295,738	341,282	263,451	273,989	259,507	265,735	256,589	305,341
Fluorspar ..... do	19,214	595	10,947	341	2,977	84	4,778	144
Gem stones	NA	85	NA	90	NA	95	NA	95
Gold (recoverable content of ores, etc.) ..... troy ounces	408,029	14,848	368,996	15,221	362,413	21,237	307,080	30,035
Iron ore (usable) ..... thousand long tons, gross weight	1,990	13,837	1,681	11,886	1,788	W	1,986	13,581
Lead (recoverable content of ores, etc.) ..... short tons	45,377	14,175	38,270	10,562	20,706	6,224	13,733	4,474
Lime ..... thousand short tons	186	3,756	172	3,569	171	4,216	185	3,804
Manganiferous ore (5% to 35% Mn) ..... short tons	700	W	112	W	--	--	--	--
Natural gas ..... million cubic feet	42,781	6,460	42,418	7,084	39,474	6,711	42,715	8,159
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels	W	W	W	W	458	1,406	W	W
LP gases ..... do	W	W	W	W	1,742	2,787	W	W
Petroleum (crude) ..... do	23,370	65,603	23,630	71,886	26,570	80,773	32,656	117,743
Pumice ..... thousand short tons	W	18	6	10	14	29	42	57
Salt ..... do	450	4,192	614	5,213	660	4,955	717	6,913
Sand and gravel ..... do	12,010	10,439	10,505	10,190	14,619	17,071	15,410	15,986
Silver (recoverable content of ores, etc.) thousand troy ounces	6,030	10,678	5,294	8,185	4,300	7,245	3,619	9,257
Stone ..... thousand short tons	1,650	4,320	2,556	5,335	3,384	6,005	2,848	6,318
Uranium (recoverable content (U_3O_8)) ..... thousand pounds	1,635	10,023	1,445	8,959	1,496	9,425	1,940	12,610
Vanadium (recoverable in ore and concentrate) short tons	257	W	226	W	188	W	142	W
Zinc (recoverable content of ores, etc.) ..... do	34,688	10,628	25,701	8,276	21,853	7,758	16,800	6,942
Value of items that cannot be disclosed: Asphalt (gilsonite), beryl concentrate, cement, clays (kaolin, 1972–73), gypsum, magnesium chloride (1972–73), magnesium compounds, molybdenum, perlite (1970), phosphate rock, potassium salts, sodium sulfate, tungsten, and values indicated by symbol W	XX	55,899	XX	49,754	XX	57,391	XX	70,408
Total	XX	602,551	XX	525,700	XX	542,809	XX	674,210

VERMONT								
Peat ----------thousand short tons--	(5)	6	W	W	(5)	1	(5)	2
Sand and gravel ----------do----	4,046	4,122	3,761	3,518	3,302	3,214	4,041	3,581
Stone ----------do----	1,514	19,088	2,496	27,940	3,300	26,170	1,871	19,523
Talc ----------short tons--	W	W	W	W	180,239	1,326	251,087	1,497
Value of items that cannot be disclosed: Asbestos, clays, gem stones, and values indicated by symbol W ----------	XX	4,627	XX	4,631	XX	4,157	XX	4,763
Total ----------	XX	27,843	XX	36,089	XX	34,868	XX	29,366
VIRGINIA								
Clays ----------thousand short tons--	1,633	1,672	1,710	1,800	1,634	1,783	1,646	1,886
Coal (bituminous) ----------do----	35,016	246,181	30,628	254,870	34,028	344,061	33,961	377,679
Gem stones ----------	NA	7	NA	12	NA	13	NA	13
Lead (recoverable content of ores, etc.) ----short tons--	3,356	1,048	3,386	934	3,441	1,034	2,637	859
Lime ----------thousand short tons--	1,046	14,090	759	11,049	758	11,739	782	12,205
Natural gas ----------million cubic feet--	2,805	864	2,619	822	2,787	892	5,101	1,688
Petroleum (crude) --------thousand 42-gallon barrels--	1	W	1	W	(5)	(5)	--	--
Sand and gravel ----------thousand short tons--	11,126	15,229	12,796	20,201	14,085	21,696	14,511	26,246
Soapstone ----------short tons--	3,760	9	3,704	8	W	W	4,600	12
Stone ----------thousand short tons--	35,415	60,477	34,643	63,482	39,986	74,090	43,895	82,719
Zinc (recoverable content of ores, etc.) ----short tons--	18,063	5,534	16,829	5,419	16,789	5,960	16,683	6,894
Value of items that cannot be disclosed: Aplite, cement, feldspar (1970–71), gypsum, kyanite, salt (1970–72), titanium concentrate (1970–71), and values indicated by symbol W ----------	XX	29,210	XX	26,564	XX	28,523	XX	30,394
Total ----------	XX	374,321	XX	385,161	XX	489,791	XX	540,595
WASHINGTON								
Cement:								
Masonry ----------thousand short tons--	6	158	5	145	6	170	6	169
Portland ----------do----	1,221	24,832	1,149	23,735	1,239	26,848	1,194	26,651
Clays [3] ----------do----	240	436	255	549	264	584	287	664
Coal (bituminous) ----------do----	37	470	1,134	7,614	2,635	17,424	3,270	21,440
Copper (recoverable content of ores, etc.) --short tons--	9	11	W	W	W	W	W	W
Gem stones ----------	NA	150	NA	155	NA	163	NA	160
Gypsum ----------thousand short tons--	--	--	W	W	5	13	W	W
Lead (recoverable content of ores, etc.) ----short tons--	6,784	2,119	5,117	1,429	2,567	772	2,217	722
Peat ----------thousand short tons--	17	71	17	72	18	89	21	110
Pumice ----------do----	W	W	W	W	W	W	1	1
Sand and gravel ----------do----	25,089	27,902	22,702	26,658	23,065	26,069	27,935	30,132
Silver (recoverable content of ores, etc.) thousand troy ounces--	W	W	W	W	221	372	W	W
Stone ----------thousand short tons--	13,701	19,100	12,436	20,489	14,712	[4] 23,764	11,384	19,284
Zinc (recoverable content of ores, etc.) ----short tons--	11,956	3,663	5,782	1,862	6,483	2,301	6,378	2,635
Value of items that cannot be disclosed: Abrasives (1971), bauxite (1970), clays (fire), diatomite, gold, lime, olivine, stone (dimension, 1972), talc, tungsten (1972–73), uranium, and values indicated by symbol W-	XX	12,010	XX	11,898	XX	11,237	XX	12,361
Total ----------	XX	90,922	XX	94,601	XX	109,806	XX	114,329

See footnotes at end of table.

Table 6.—Mineral production[1] in the United States, by State—Continued

Mineral	1970 Quantity	1970 Value (thousands)	1971 Quantity	1971 Value (thousands)	1972 Quantity	1972 Value (thousands)	1973 Quantity	1973 Value (thousands)
WEST VIRGINIA								
Clays[3] ---thousand short tons	191	$238	232	$336	274	$403	348	$516
Coal (bituminous) ---do	144,072	1,142,245	118,258	1,128,282	123,743	1,275,813	115,448	1,340,338
Gem stones	NA	W	NA	2	NA	2	NA	2
Lime ---thousand short tons	262	3,757	197	3,073	W	W	W	W
Natural gas ---million cubic feet	242,452	61,583	234,027	60,613	214,951	64,485	208,676	64,481
Petroleum (crude) ---thousand 42-gallon barrels	3,124	11,871	2,969	11,609	2,677	12,047	2,385	11,965
Salt ---thousand short tons	1,190	5,171	1,174	4,778	1,232	5,963	1,217	6,082
Sand and gravel ---do	4,396	11,473	7,107	16,756	5,765	15,031	5,893	16,257
Stone[4] ---do	9,740	16,722	9,880	18,066	11,649	21,293	11,732	22,821
Value of items that cannot be disclosed: Cement, clays (fire), natural gas liquids, stone (dimension), and values indicated by symbol W	XX	32,304	XX	30,445	XX	35,595	XX	40,583
Total	XX	1,285,364	XX	1,273,960	XX	1,430,632	XX	1,503,045
WISCONSIN								
Clays ---thousand short tons	8	14	4	8	4	7	2	3
Gem stones	NA	W	NA	W	NA	1	NA	1
Iron ore (usable) ---thousand long tons, gross weight	806	W	824	W	887	W	956	W
Lead (recoverable content of ores, etc.) ---short tons	761	238	752	207	757	228	844	275
Lime ---thousand short tons	247	4,503	246	4,570	263	5,009	310	6,004
Peat ---do	2	W	2	153	2	179	2	208
Sand and gravel ---do	41,103	35,107	38,561	32,748	36,430	31,324	40,250	43,647
Stone ---do	17,577	25,167	15,568	25,105	19,394	29,681	23,818	36,917
Zinc (recoverable content of ores, etc.) ---short tons	20,634	6,322	10,645	3,428	6,873	2,440	8,672	3,583
Value of items that cannot be disclosed: Abrasive stones, cement, and values indicated by symbol W	XX	16,319	XX	17,817	XX	20,484	XX	23,701
Total	XX	87,670	XX	84,036	XX	89,353	XX	114,339
WYOMING								
Clays ---thousand short tons	1,950	18,829	1,798	17,378	1,873	18,509	2,343	24,043
Coal (bituminous) ---do	7,222	24,423	8,052	27,335	10,928	40,898	14,886	60,939
Feldspar ---short tons	W	W	W	W	W	W	2,588	56
Gem stones	NA	130	NA	135	NA	142	NA	142
Gypsum ---thousand short tons	216	868	232	918	W	W	312	1,348
Iron ore (usable) ---thousand long tons, gross weight	W	W	1,808	W	2,030	W	2,070	W
Lime ---thousand short tons	22	W	27	W	W	W	30	548
Natural gas ---million cubic feet	338,520	49,762	380,105	58,156	375,059	60,760	357,731	64,749
Natural gas liquids:								
Natural gasoline ---thousand 42-gallon barrels	2,597	7,085	2,514	7,415	3,015	8,951	3,351	10,647
LP gases ---do	4,556	7,472	5,474	10,127	7,691	15,536	7,237	22,507
Petroleum (crude) ---do	160,345	469,811	148,114	459,079	140,011	432,071	141,914	541,820
Sand and gravel ---thousand short tons	9,447	9,298	9,820	8,750	9,098	14,916	6,201	11,635
Stone ---do	1,266	2,758	2,894	4,789	3,549	5,768	3,191	6,716

Uranium (recoverable content U_3O_8) --thousand pounds--	6,346	38,768	6,986	43,311	8,544	53,827	10,060	65,390
Value of items that cannot be disclosed: Cement, phosphate rock, pumice (1972–73), sodium carbonate, sodium sulfate (1970), and values indicated by symbol W ----	XX	76,329	XX	80,544	XX	95,365	XX	117,565
Total	XX	705,533	XX	717,937	XX	746,743	XX	928,105

[r] Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Excludes certain cement, included with "Value of items that cannot be disclosed."
[3] Excludes certain clays, included with "Value of items that cannot be disclosed."
[4] Excludes certain stones, included with "Value of items that cannot be disclosed."
[5] Less than ½ unit.
[6] Excludes salt in brine, included with "Value of items that cannot be disclosed."

Table 7.—Mineral production[1] in the Canal Zone and islands administered by the United States

Area and mineral	1970		1971		1972		1973	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
American Samoa:								
Pumice thousand short tons	2	$6	10	$35	--	--	37	$214
Sand and gravel do	26	25	--	--	--	--	--	--
Stone do	49	69	33	30	49	$414	63	152
Total	XX	100	XX	65	XX	414	XX	366
Canal Zone:								
Sand and gravel thousand short tons	60	97	--	--	--	--	--	--
Stone do	85	265	--	--	--	--	--	--
Total	XX	362	XX	--	XX	--	XX	--
Guam: Stone thousand short tons	636	1,289	718	1,705	831	1,983	1,246	3,139
Virgin Islands: Stone do	514	2,226	543	W	726	2,255	664	2,860
Wake: Stone do	4	18	3	16	--	--	--	--

W Withheld to avoid disclosing individual company confidential data. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

Table 8.—Mineral production[1] in the Commonwealth of Puerto Rico

Mineral	1970		1971		1972		1973	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement thousand short tons	1,778	$29,515	2,001	$38,413	1,946	$31,756	2,062	$41,203
Clays do	429	486	342	358	361	382	464	473
Lime do	41	W	44	W	42	1,776	42	2,215
Salt do	32	395	29	570	29	580	29	580
Sand and gravel do	11,506	28,001	12,998	34,980	7,478	21,237	7,480	21,243
Stone do	7,296	13,947	12,130	29,847	13,504	32,793	15,647	41,857
Total	XX	[2] 72,344	XX	[2] 104,168	XX	88,524	XX	107,571

W Withheld to avoid disclosing individual company confidential data. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Total does not include value of items withheld.

Table 9.—U.S. exports of principal minerals and products

Mineral	1972 Quantity	1972 Value (thousands)	1973 Quantity	1973 Value (thousands)
METALS				
Aluminum:				
Ingots, slabs, crude ---- short tons--	108,319	$51,879	229,578	$121,951
Scrap ---- do----	66,039	21,072	115,120	39,936
Plates, sheets, bars, etc ---- do----	144,987	115,279	202,371	178,482
Castings and forgings ---- do----	4,467	11,681	5,277	14,613
Aluminum sulfate ---- do----	4,968	181	21,134	642
Other aluminum compounds ---- do----	942,084	83,490	836,659	92,643
Antimony: Metals and alloys crude ---- do----	121	85	515	469
Bauxite, including bauxite concentrates thousand long tons--	29	1,299	12	811
Beryllium ---- pounds--	95,492	839	109,199	1,220
Bismuth: Metals and alloys ---- do----	264,276	493	151,053	446
Cadmium ---- thousand pounds--	1,017	2,363	305	598
Chrome:				
Ore and concentrates:				
Exports ---- thousand short tons--	20	824	21	789
Reexports ---- do----	57	1,946	34	989
Ferrochrome ---- do----	13	4,342	15	5,091
Cobalt ---- thousand pounds--	2,597	5,005	3,890	8,932
Columbium metals, alloys and other forms do----	29	453	96	790
Copper:				
Ore, concentrate, composition metal and unrefined (copper content) ---- short tons--	r 35,612	26,548	45,957	48,559
Refined copper and semimanufactures -do----	215,591	278,059	242,856	386,993
Other copper manufactures ---- do----	6,299	7,400	7,431	12,160
Copper sulfate or blue vitriol ---- do----	2,646	1,767	1,716	2,043
Copper-base alloys ---- do----	90,377	105,586	149,888	205,249
Ferroalloys:				
Ferrosilicon ---- do----	7,367	2,196	15,984	4,051
Ferrophosphorus ---- do----	1,179	111	19,030	773
Gold:				
Ore and base bullion ---- troy ounces--	265,783	14,531	334,255	29,692
Bullion, refined ---- do----	1,206,386	48,522	2,650,962	116,273
Iron ore ---- thousand long tons--	2,095	26,776	2,747	37,922
Iron and steel:				
Pig iron ---- short tons--	15,018	931	15,160	882
Iron and steel products (major):				
Semimanufactures ---- do----	2,309,583	400,820	3,317,118	713,292
Manufactured steel mill products -do----	1,236,897	605,600	1,644,412	867,594
Iron and steel scrap: Ferrous scrap, including rerolling materials thousand short tons--	7,683	252,617	11,412	606,556
Lead:				
Pigs, bars, anodes ---- short tons--	8,376	4,500	66,576	27,097
Scrap ---- do----	35,233	4,264	59,873	12,227
Magnesium: Metal and alloys and semimanufactured forms, n.e.c ---- do----	17,556	11,702	39,585	28,242
Manganese:				
Ore and concentrate ---- do----	25,108	3,137	57,448	4,535
Ferromanganese ---- do----	6,842	1,512	8,574	2,137
Mercury:				
Exports ---- 76-pound flasks--	400	129	342	170
Reexports ---- do----	563	121	--	--
Molybdenum:				
Ore and concentrates (molybdenum content) ---- thousand pounds--	45,362	73,039	73,958	120,387
Metals and alloys, crude and scrap --do----	89	199	148	252
Wire ---- do----	173	1,551	357	3,105
Semifabricated forms, n.e.c ---- do----	181	987	209	1,216
Powder ---- do----	50	192	195	672
Ferromolybdenum ---- do----	r 909	1,163	2,224	3,151
Nickel:				
Alloys and scrap (including Monel metal), ingots, bars, sheets, etc ---- short tons--	16,694	42,677	16,545	50,712
Catalysts ---- do----	2,573	6,794	2,478	6,584
Nickel-chrome electric resistance wire-do----	553	2,638	697	3,818
Semifabricated forms, n.e.c ---- do----	1,851	11,659	2,350	14,689
Platinum:				
Ore, concentrate, metal and alloys in ingots, bars, sheets, anodes, and other forms, including scrap ---- troy ounces--	417,037	r 44,258	439,452	61,379
Palladium, rhodium, iridium, osmiridium, ruthenium, and osmium (metal and alloys including scrap) ---- do----	r 121,957	r 7,518	188,074	16,246
Platinum-group manufactures, except jewelry	NA	4,255	NA	4,282

See footnotes at end of table.

Table 9.—U.S. exports of principal minerals and products—Continued

Mineral	1972 Quantity	1972 Value (thousands)	1973 Quantity	1973 Value (thousands)
METALS—Continued				
Rare earths: Cerium ore, metal, alloys, lighter flints ____ pounds__	202,206	$610	109,766	$286
Silver:				
Ore, concentrates, waste and sweepings thousand troy ounces__	2,964	4,899	3,007	7,322
Bullion, refined ____ do____	26,693	44,361	8,208	20,316
Tantalum:				
Ore, metal, other forms ___thousand pounds__	r 165	r 2,310	360	3,962
Powder ____ do____	171	3,572	202	5,312
Tin:				
Ingots, pigs, bars, etc.:				
Exports ____ long tons__	857	2,915	2,540	12,099
Reexports ____ do____	277	1,055	866	3,236
Tin scrap and other tin-bearing material except tinplate scrap ____ do____	8,548	3,392	4,862	3,262
Titanium:				
Ore and concentrate ____ short tons__	1,802	394	1,494	353
Sponge (including iodide titanium and scrap) ____ do____	3,510	2,165	4,142	3,601
Intermediate mill shapes and mill products, n.e.c ____ do____	562	6,265	745	8,748
Dioxide and pigments ____ do____	r 10,335	4,882	20,769	14,021
Tungsten: Ore and concentrates:				
Exports ____ thousand pounds__	95	211	90	239
Reexports ____ do____	--	--	--	--
Vanadium ore and concentrate, pentoxide, etc. (vanadium content) ____ do____	351	756	464	1,157
Zinc:				
Slabs, pigs, or blocks ____ short tons__	4,324	714	14,566	8,259
Sheets, plates, strips, or other forms, n.e.c ____ do____	2,419	2,138	2,480	2,100
Scrap (zinc content) ____ do____	1,446	431	7,032	2,717
Semifabricated forms, n.e.c ____ do____	6,052	3,076	15,077	10,565
Zirconium:				
Ore and concentrate ____ do____	17,360	940	28,921	2,288
Metals, alloys, other forms ____ pounds__	1,314,219	11,509	1,016,437	12,425
NONMETALS				
Abrasives:				
Dust and powder of precious or semiprecious stones, including diamond dust and powder ____ thousand carats__	8,263	21,986	9,928	25,071
Crushing bort ____ do____	55	305	40	138
Industrial diamonds ____ do____	484	1,899	516	4,208
Diamond grinding wheels ____ do____	554	3,073	746	4,223
Other natural and artificial metallic abrasives and products ____	NA	36,956	NA	49,329
Asbestos, unmanufactured:				
Exports ____ short tons__	51,792	7,621	65,900	9,251
Reexports ____ do____	6,832	1,430	542	91
Boron: Boric acid, borates, crude and refined ____ do____	189,778	22,530	210,233	26,216
Cement ____ do____	100,889	3,712	324,740	8,980
Clays:				
Kaolin or china clay ____ do____	667,519	26,332	731,798	30,528
Fire clay ____ do____	124,307	2,905	196,337	3,820
Other clays ____ do____	1,053,892	36,979	1,168,495	45,426
Fluorspar ____ do____	2,764	184	2,478	196
Graphite ____ do____	7,289	888	7,953	992
Gypsum:				
Crude, crushed or calcined thousand short tons__	51	2,582	63	3,135
Manufactures, n.e.c ____	NA	2,694	NA	4,225
Kyanite and allied minerals ____ short tons__	73,911	3,737	93,714	5,552
Lime ____ do____	37,659	1,242	36,914	1,208
Mica sheet, waste and scrap and ground ____ pounds__	13,957,313	1,842	14,588,464	2,201
Mica, manufactured ____ do____	1,001,639	2.910	1,155,852	3,064
Mineral-earth pigments: Iron oxide, natural and manufactured ____ short tons__	8,194	5,087	14,363	6,702
Nitrogen compounds (major) thousand short tons__	4,004	222,441	4,538	318,436
Phosphate rock ____ do____	13,992	107,438	13,932	113,295
Phosphatic fertilizers (superphosphates) __do____	967	52,465	967	70,990

See footnotes at end of table.

Table 9.—U.S. exports of principal minerals and products—Continued

Mineral	1972 Quantity	1972 Value (thousands)	1973 Quantity	1973 Value (thousands)
NONMETALS—Continued				
Pigments and compounds(lead and zinc):				
Lead pigments ----------------short tons--	1,867	$818	2,240	$1,025
Zinc pigments ----------------------do----	7,567	2,764	8,624	3,440
Potash:				
Fertilizer --------------------------do----	1,353,471	45,858	1,578,716	57,997
Chemical ---------------------------do----	31,435	6,890	39,229	10,660
Quartz, natural, quartzite, cryolite, chiolite ------------------------------do----	677	130	724	134
Salt:				
Crude and refined -----thousand short tons--	869	5,544	609	4,400
Shipments to noncontiguous Territories ----------------------do----	21	2,303	18	1,585
Sodium and sodium compounds:				
Sodium sulfate ---------------------do----	29	926	45	2,049
Sodium carbonate ------------------do----	480	r 18,911	425	16,064
Stone:				
Dolomite, block --------------------do----	77	1,025	59	652
Limestone, crushed, ground, broken --do----	1,730	3,802	2,316	5,400
Marble and other building and monumental thousand cubic feet--	NA	755	NA	1,244
Stone, crushed, ground, broken thousand short tons--	1,035	4,298	765	4,819
Manufactures of stone -------------------	NA	1,227	NA	948
Sulfur:				
Crude ---------------thousand long tons--	1,847	32,409	1,771	34,330
Crushed, ground, flowers of ----------do----	5	1,278	6	1,461
Talc, crude and ground ------------short tons--	171,007	5,791	180,102	6,618
MINERAL FUELS				
Carbon black ---------------thousand pounds--	r 111,238	r 14,856	192,665	24,056
Coal:				
Anthracite ------------thousand short tons--	743	10,922	717	11,240
Bituminous -------------------------do----	r 55,997	r 973,189	52,903	1,002,457
Briquets ---------------------------do----	r 73	r 4,264	92	5,107
Coke ------------------------------do----	1,232	30,720	1,395	33,138
Natural gas -------------thousand cubic feet--	89,499,088	42,176	84,805,211	43,152
Petroleum:				
Crude -----------------thousand barrels--	192	565	697	2,620
Gasoline ---------------------------do----	493	4,396	1,692	20,737
Jet fuel ---------------------------do----	258	r 1,113	824	4,087
Naphtha ---------------------------do----	1,438	r 16,397	1,561	19,671
Kerosine ---------------------------do----	84	778	81	811
Distillate fuel oil ------------------do----	755	3,055	2,526	25,680
Residual fuel oil -------------------do----	11,576	34,349	8,388	23,578
Lubricating oil ---------------------do----	12,149	169,424	10,728	173,546
Asphalt ----------------------------do----	r 331	3,572	338	3,262
Liquefied petroleum gases -----------do----	11,475	46,581	9,927	57,191
Wax -------------------------------do----	1,105	25,840	942	24,176
Coke ------------------------------do----	30,667	111,950	34,668	127,182
Petrochemical feedstocks ------------do----	r 4,545	r 23,215	6,815	32,500
Miscellaneous ----------------------do----	1,042	r 21,310	1,168	27,886
Total ---------------------------------	XX	r 4,634,224	XX	6,535,790

r Revised. NA Not available. XX Not applicable.

Table 10.—U.S. imports for consumption of principal minerals and products

Mineral	1972 Quantity	1972 Value (thousands)	1973 Quantity	1973 Value (thousands)
METALS				
Aluminum:				
Metal ---short tons--	661,042	$304,536	508,025	$225,256
Scrap ---do---	52,301	17,747	46,808	16,740
Plates, sheets, bars, etc ---do---	r 81,142	r 52,451	58,773	43,222
Aluminum oxide (alumina) ---do---	2,849,995	173,413	3,375,488	209,329
Antimony:				
Ore (antimony content) ---do---	17,212	9,437	16,679	10,903
Needle or liquated ---do---	78	75	51	73
Metal ---do---	2,302	2,092	692	745
Oxide ---do---	5,032	5,766	4,651	6,095
Arsenic: White (As_2O_3 content) ---do---	13,613	1,956	11,496	1,714
Bauxite: Crude ---thousand long tons--	11,428	151,012	11,240	143,075
Beryllium ore ---short tons--	3,345	1,101	1,586	481
Bismuth ---pounds--	1,562,934	5,235	2,676,271	9,655
Boron carbide ---do---	11,622	61	322,236	395
Cadmium:				
Metal ---short tons--	r 1,211	4,886	1,946	12,799
Flue dust (cadmium content ---do---	r 370	685	82	243
Calcium:				
Metal ---pounds--	248,080	r 181	110,407	78
Chloride ---short tons--	6,128	225	7,357	317
Chromate:				
Ore and concentrates (Cr_2O_3 content) thousand short tons--	r 499	r 27,605	412	21,028
Ferrochrome ---do---	90	34,588	100	35,175
Metal ---do---	2	3,791	3	6,080
Cobalt:				
Metal ---thousand pounds--	13,082	30,650	18,360	53,625
Oxide (gross weight) ---do---	1,134	2,330	1,150	2,714
Salts and compounds (gross weight) --do---	82	44	r 62	r 51
Columbium ore ---do---	3,227	1,927	2,826	2,201
Copper: (copper content)				
Ore and concentrates ---short tons--	80,740	81,055	19,582	16,029
Regulus, black, coarse ---do---	1,453	1,134	139	106
Unrefined, black, blister ---do---	77,162	72,514	128,166	159,922
Refined in ingots, etc ---do---	175,703	172,772	206,297	262,706
Old and scrap ---do---	10,787	9,766	18,266	21,967
Ferroalloys: Ferrosilicon (silicon content) ---do---	23,154	8,815	63,388	21,087
Gold:				
Ore and base bullion ---troy ounces--	265,453	14,023	234,692	19,388
Bullion ---do---	5,860,749	343,666	3,610,073	336,762
Iron ore ---thousand long tons--	35,761	415,934	43,296	533,488
Iron and steel:				
Pig iron ---short tons--	636,932	33,518	445,626	28,925
Iron and steel products (major):				
Iron products ---do---	41,428	18,158	38,043	19,113
Steel products ---do---	18,117,041	r 2,974,072	15,571,833	3,026,099
Scrap ---do---	295,000	14,304	336,693	18,716
Tinplate ---do---	17,040	437	11,940	384
Lead:				
Ore, flue dust, matte (lead content) --do---	51,642	10,554	94,355	17,409
Base bullion (lead content) ---do---	895	238	4	1
Pigs and bars (lead content) ---do---	245,598	64,096	178,095	52,927
Reclaimed scrap, etc. (lead content) --do---	1,753	450	2,745	522
Sheet, pipe, shot ---do---	r 179	r 69	38	18
Magnesium:				
Metallic and scrap ---do---	4,298	1,990	2,874	1,404
Alloys (magnesium content) ---do---	168	464	389	1,104
Sheets, tubing, ribbons, wire and other forms (magnesium content) --do---	13	103	20	129
Manganese:				
Ore (35% or more manganese) (manganese content) ---do---	792,695	34,315	722,635	37,403
Ferromanganese (manganese content)-do---	274,717	49,846	303,867	53,308
Mercury:				
Compounds ---pounds--	9,028	45	3,543	30
Metal ---76-pound flasks--	28,834	r 5,881	46,026	12,151
Minor metals: Selenium and salts ---pounds--	448,964	4,362	590,173	6,023
Nickel:				
Pigs, ingots, shot, cathodes ---short tons--	125,364	r 330,825	120,083	343,494
Scrap ---do---	2,306	3,517	2,642	3,906
Oxide ---do---	5,988	12,038	6,301	13,466
Platinum group:				
Unwrought:				
Grains and nuggets (platinum) troy ounces--	58,284	7,254	19,146	2,396

See footnotes at end of table.

Table 10.—U.S. imports for consumption of principal minerals and products—Continued

Mineral	1972 Quantity	1972 Value (thousands)	1973 Quantity	1973 Value (thousands)
METALS—Continued				
Platinum group—Continued				
Unwrought—Continued				
Sponge (platinum) troy ounces	350,143	$42,622	499,271	$73,108
Sweepings, waste, scrap do	75,210	7,600	84,534	10,229
Iridium do	24,827	4,038	19,701	4,816
Palladium do	289,055	12,929	496,065	36,613
Rhodium do	47,378	8,735	72,856	15,587
Ruthenium do	61,191	2,602	67,218	3,375
Other platinum-group metals do	r 103,419	r 12,134	243,584	33,877
Semimanufactured:				
Platinum do	207,960	22,869	155,715	22,949
Palladium do	613,174	22,488	658,240	43,500
Rhodium do	3,426	543	20,355	1,761
Other platinum-group metals do	r 2,282	r 278	3,806	621
Radium: Radioactive substitutes	NA	4,444	NA	5,537
Rare earths: Ferrocerium and other cerium alloys pounds	27,867	94	38,206	127
Silver:				
Ore and base bullion thousand troy ounces	33,768	49,979	33,990	74,927
Bullion do	25,680	41,579	81,219	215,697
Tantalum ore thousand pounds	1,229	2,663	1,097	2,858
Tin:				
Ore (tin content) long tons	4,216	12,475	4,480	17,081
Blocks, pigs, grains, etc do	52,451	195,421	45,845	195,246
Dross, skimmings, scrap, residues and tin alloys, n.s.p.f do	1,304	2,140	1,281	1,322
Tin foil, powder, flitters, etc	NA	6,501	NA	6,956
Titanium:				
Ilmenite [1] short tons	395,218	14,237	453,650	16,981
Rutile do	195,068	21,733	174,180	23,786
Metal pounds	8,769,356	8,041	13,648,385	11,389
Ferrotitanium do	181,326	76	512,547	178
Compounds and mixtures do	173,597,069	33,908	121,789,426	28,057
Tungsten: (tungsten content)				
Ore and concentrates thousand pounds	5,739	12,139	10,552	23,037
Metal do	r 122	342	93	276
Other alloys do	r 1,091	r 3,541	1,433	4,947
Zinc:				
Ore (zinc content) short tons	174,063	24,275	153,898	24,667
Blocks, pigs, slabs do	516,643	176,707	587,429	270,213
Sheets do	485	310	236	159
Old, dross, skimmings do	2,882	r 592	4,052	1,074
Dust do	9,197	3,822	4,671	2,298
Manufactures	NA	2,040	NA	3,407
Zirconium: Ore, including zirconium sand do	67,537	3,291	98,023	5,415
NONMETALS				
Abrasives: Diamonds (industrial) thousand carats	15,134	52,619	19,154	65,594
Asbestos short tons	735,515	87,732	792,473	98,914
Barite:				
Crude and ground do	624,634	5,658	724,813	7,767
Witherite do	1,311	169	4,611	716
Chemicals do	23,592	3,959	32,780	6,719
Cement do	r 4,911	r 71,757	6,683	104,084
Clays:				
Raw do	62,576	1,095	46,044	1,303
Manufactured do	4,138	214	6,598	576
Cryolite do	25,642	3,451	38,276	5,104
Feldspar: Crude long tons	167	23	264	22
Fluorspar short tons	1,181,533	47,851	1,212,347	52,620
Gem stones:				
Diamond thousand carats	5,506	626,679	[2] 5,181	[2] 821,090
Emeralds do	573	22,176	749	32,600
Other	NA	67,281	NA	83,968
Graphite short tons	64,135	3,847	77,376	4,455
Gypsum:				
Crude, ground, calcined thousand short tons	7,720	18,494	7,663	17,695
Manufactures	NA	3,548	NA	4,242
Iodine, crude thousand pounds	6,207	10,184	6,118	10,484
Kyanite short tons	124	6	221	13
Lime:				
Hydrated do	37,468	724	47,309	941
Other do	210,995	3,224	286,703	4,302
Magnesium compounds:				
Crude magnesite short tons	--	--	--	--

See footnotes at end of table.

Table 10.—U.S. imports for consumption of principal minerals and products—Continued

Mineral	1972		1973	
	Quantity	Value (thousands)	Quantity	Value (thousands)
NONMETALS—Continued				
Magnesium compounds—Continued				
Lump, ground, caustic calcined magnesia ---short tons--	10,376	$675	10,967	$734
Refractory magnesia, dead-burned fused magnesite, dead-burned dolomite ---do----	133,734	9,695	158,007	13,877
Compounds ---do----	25,301	1,111	57,029	1,880
Mica:				
Uncut sheet and punch --thousand pounds--	1,494	1,162	1,169	1,269
Scrap ---do----	2,641	62	5,072	116
Manufactures ---do----	5,644	3,183	4,785	4,325
Mineral-earth pigments: Iron oxide pigments:				
Natural ---short tons--	2,777	236	1,858	378
Synthetic ---do----	34,274	7,602	37,436	10,700
Ocher, crude and refined ---do----	93	6	66	9
Siennas, crude and refined ---do----	1,272	196	1,192	205
Umber, crude and refined ---do----	8,234	412	9,665	569
Vandyke brown ---do----	621	77	966	144
Nitrogen compounds (major), including urea thousand short tons--	2,683	125,037	2,837	146,455
Phosphate, crude ---do----	[2] 55	[2] 1,416	[2] 65	[2] 1,288
Phosphatic fertilizers ---do----	70	3,184	68	3,042
Pigments and salts:				
Lead pigments and compounds short tons--	26,550	9,244	20,515	8,602
Zinc pigments and compounds ---do----	25,934	6,891	36,479	13,792
Potash ---do----	4,996,415	128,548	6,082,444	157,800
Pumice:				
Crude or unmanufactured ---do----	9,094	149	5,026	95
Wholly or partly manufactured ---do----	589,758	1,351	305,400	1,038
Manufactures, n.s.p.f ---	NA	24	NA	19
Quartz crystal (Brazilan pebble) ---pounds--	r 762,740	331	1,064,774	364
Salt ---thousand short tons--	3,463	11,979	3,187	12,457
Sand and gravel:				
Glass sand ---do----	49	201	48	340
Other sand and gravel ---do----	712	1,178	752	1,236
Sodium sulfate ---do----	299	5,358	320	5,658
Stone and whiting ---	NA	r 43,436	NA	48,678
Strontium: Mineral ---short tons--	30,677	830	27,040	657
Sulfur and pyrites:				
Sulfur ore and other forms n.e.s. thousand long tons--	1,138	16,288	1,222	14,742
Pyrites ---do----	125	472	20	113
Talc: Unmanufactured ---short tons--	29,085	1,669	22,993	1,658
MINERAL FUELS				
Carbon black:				
Acetylene ---pounds--	6,022,118	1,581	7,268,499	2,030
Gas black and carbon black ---do----	1,149,099	176	8,669,196	991
Coal:				
Bituminous, slack, culm and lignite short tons--	47,098	691	126,641	1,607
Briquets ---do----	5,849	96	7,425	123
Coke ---do----	185,023	4,649	1,077,737	39,263
Natural gas, ethane, methane, and mixtures thereof ---thousand cubic feet-	r 1,307,774,412	r 403,151	995,329,121	341,470
Peat:				
Fertilizer grade ---short tons--	307,233	16,951	317,639	18,390
Poultry and stable grade ---do----	r 3,288	222	5,862	372
Petroleum:				
Crude petroleum ---thousand barrels--	896,991	2,369,176	1,295,719	4,231,682
Distillate fuel oil ---do----	107,905	254,529	188,553	716,651
Residual fuel oil ---do----	r 480,031	r 1,170,366	548,265	1,860,279
Unfinished oils ---do----	1,812	5,324	3,103	34,365
Gasoline ---do----	1,744	8,730	17,330	139,528
Jet fuel ---do----	r 65,572	r 222,891	71,819	294,951
Motor fuels, n.e.s ---do----	171	669	1,303	7,672
Kerosine ---do----	270	1,299	1,078	6,946
Lubricants ---do----	r 970	r 988	2,023	1,516
Wax ---do----	73	1,342	380	8,899
Naphtha ---do----	86,279	213,857	97,469	334,939
Liquefied petroleum gases ---do----	32,485	73,340	47,873	151,259
Asphalt ---do----	9,653	23,852	8,669	20,868
Miscellaneous ---do----	10,573	36,810	13,339	51,596
Total ---	XX	r 12,498,581	XX	17,035,294

r Revised. NA Not available. XX Not applicable.
[1] Includes titanium slag averaging about 70% TiO_2. For detail see Titanium Chapter, table 5.
[2] Adjusted by Bureau of Mines.

Table 11.—Comparison of world and United States production of principal mineral commodities

(Thousand short tons unless otherwise specified)

Minerals	1972 World production [1]	1972 U.S. production	1972 U.S. percent of world production	1973 p World production [1]	1973 p U.S. production	1973 p U.S. percent of world production
MINERAL FUELS						
Carbon black ----- million pounds--	7,059	3,201	45	7,721	3,500	45
Coal:						
Bituminous ----------------	[2] 2,343,848	584,387	25	[2] 2,385,506	577,574	24
Lignite ----------------	886,414	10,999	1	903,072	14,164	2
Pennsylvania anthracite -------	192,612	7,106	4	191,919	6,830	4
Coke (excluding breeze):						
Gashouse [3] ----------------	21,671	--	--	20,787	--	--
Oven and beehive ------------	381,315	60,507	16	401,849	64,325	16
Natural gas (marketable) million cubic feet--	42,568,899	22,531,698	53	45,917,032	22,647,549	49
Peat ----------------	116,029	577	([4])	106,481	635	1
Petroleum (crude) thousand barrels--	18,600,501	3,455,368	19	20,560,852	3,360,903	16
NONMETALS						
Asbestos ----------------	4,160	132	3	4,606	150	3
Barite ----------------	4,362	906	21	4,761	1,104	23
Cement ----------------	728,601	[5] 84,556	12	780,349	[5] 87,498	11
China clay ----------------	15,352	[6] 5,318	35	16,390	[6] 5,993	37
Corundum ----------------	8	--	--	NA	--	--
Diamond ---------thousand carats--	43,810	--	--	43,489	--	--
Diatomite ----------------	1,700	576	34	1,738	609	35
Feldspar ----------------	2,805	732	26	2,794	792	28
Fluorspar ----------------	4,974	250	5	4,928	249	5
Graphite ----------------	398	W	NA	NA	W	NA
Gypsum ----------------	66,142	12,328	19	67,032	13,558	20
Lime (sold or used) ------------	113,566	[5] 20,332	18	118,820	[5] 21,132	18
Magnesite ----------------	9,842	W	NA	9,864	W	NA
Mica (including scrap) thousand pounds--	525,709	319,086	61	577,276	354,152	61
Nitrogen, agricultural [7] ----------	38,716	[5] 8,919	23	42,202	[5] 9,339	22
Phosphate rock ----------------	98,981	40,831	41	108,060	42,137	39
Potash (K_2O equivalent) ----------	22,497	2,659	12	24,212	2,603	11
Pumice [8] ----------------	17,465	3,819	22	15,698	3,772	24
Pyrites ------thousand long tons--	22,783	741	3	22,038	559	3
Salt ----------------	162,941	[5] 45,050	28	165,526	[5] 43,940	27
Strontium [8] ----------------	110	--	--	103	--	--
Sulfur, elemental thousand long tons--	28,209	9,240	33	31,555	10,021	32
Talc, pyrophyllite, soapstone ------	5,241	1,107	21	5,666	1,247	22
Vermiculite [8] ----------------	512	337	66	551	365	66
METALS, MINE BASIS						
Antimony, (content of ore and concentrate) ----short tons--	73,259	489	1	76,419	545	1
Arsenic, white ----------do----	46,338	--	NA	52,317	W	NA
Bauxite ------thousand long tons--	64,021	[9] 1,812	3	69,614	[9] 1,879	3
Beryl ----------short tons--	4,634	W	NA	4,291	W	NA
Bismuth --------thousand pounds--	8,330	W	NA	8,798	W	NA
Chromite ----------------	6,977	--	--	7,507	--	--
Cobalt (contained) ----short tons--	25,925	--	--	28,255	--	--
Columbium-tantalum concentrate [8] thousand pounds--	34,309	--	--	53,001	--	--
Copper (content of ore and concentrate) ----------------	7,329	[10] 1,665	23	7,857	[10] 1,718	22
Gold -------thousand troy ounces--	44,718	1,450	3	43,070	1,176	3
Iron ore ------thousand long tons--	767,679	[11] 75,434	10	850,477	[11] 87,669	10
Lead (content of ore and concentrate) ----------------	3,764	[10] 619	16	3,806	[10] 603	16
Manganese ore (35% or more Mn)--	22,990	1	([4])	24,290	([4])	([4])
Mercury-thousand 76-pound flasks--	278	7	3	276	2	1
Molybdenum (content of ore and concentrate) ---thousand pounds--	174,418	112,138	64	181,152	115,859	64
Nickel (content of ore and concentrate) ----------------	683	17	2	726	18	2
Platinum group thousand troy ounces--	4,269	17	([4])	5,174	20	([4])
Silver ----------------do----	294,159	37,233	13	305,916	37,827	12
Tin (content of ore and concentrate) ---------long tons--	239,610	W	NA	232,404	W	NA
Titanium concentrates:						
Ilmenite [8] ----------------	2,668	682	26	2,939	804	27
Rutile [8] ----------------	357	--	--	368	--	--

See footnotes at end of table.

Table 11.—Comparison of world and United States production of principal mineral commodities—Continued

(Thousand short tons unless otherwise specified)

Minerals	1972 World production [1]	1972 U.S. production	1972 U.S. percent of world production	1973 p World production [1]	1973 p U.S. production	1973 p U.S. percent of world production
METALS, MINE BASIS—Continued						
Tungsten concentrate (contained tungsten) thousand pounds	84,470	8,150	10	85,320	7,575	9
Uranium oxide (U_3O_8) [8] short tons	25,625	12,900	50	25,486	13,235	52
Vanadium (content of ore and concentrate) short tons	20,679	4,887	24	21,285	4,377	21
Zinc (content of ore and concentrate)	6,221	478	8	6,377	479	8
METALS, SMELTER BASIS						
Aluminum	12,115	4,122	34	13,359	4,529	34
Cadmium short tons	18,388	[12] 4,145	23	18,747	[12] 3,714	20
Copper	7,340	[13] 1,690	23	7,838	[13] 1,744	22
Iron, pig	502,768	88,876	18	555,852	100,929	18
Lead	3,745	[14] 689	18	3,801	[14] 688	18
Magnesium	256	121	47	261	122	47
Selenium [8] thousand pounds	2,687	739	28	2,458	627	26
Steel ingots and castings	692,557	[15] 133,241	19	765,832	[15] 150,799	20
Tellurium [8] thousand pounds	384	257	67	420	241	57
Tin long tons	236,473	[16] 4,300	2	227,251	[16] 4,500	2
Zinc	5,646	633	11	5,795	541	9

p Preliminary. r Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data.

[1] May not represent total world production because confidential U.S. data are excluded for some commodities. World totals include reported figures and reasonable estimates; however, for some commodities where data were not available, no reasonable estimates could be made and none have been included.

[2] Includes small quantities of lignite for People's Republic of China, and Pakistan, and anthracite for Colombia.

[3] Includes low- and medium-temperature and gashouse coke.

[4] Less than ½ unit.

[5] Includes Puerto Rico.

[6] Kaolin sold or used by producers.

[7] Year ended June 30 of year stated (United Nations).

[8] World total exclusive of the U.S.S.R.

[9] Dry bauxite equivalent of crude ore.

[10] Recoverable.

[11] Includes byproduct ore.

[12] Includes secondary.

[13] Smelter output from domestic and foreign ores, exclusive of scrap.

[14] Lead refined from domestic and foreign ores; excludes lead refined from imported base bullion.

[15] Data from American Iron and Steel Institute. Excludes production of castings by companies that do not produce steel ingot.

[16] Includes tin content of alloys made directly from ore.

Abrasive Materials

By Robert G. Clarke [1]

The output of natural abrasives increased 16% in both quantity and value compared with that of 1972, excluding the value of emery. Production of tripoli-type crudes increased 16% in quantity and 17% in value. The output of silica stone products increased 7% in quantity and 1% in value. The production of garnet increased 20% in quantity and 22% in value. The production of emery was essentially unchanged in quantity.

Overall, the production of artificial abrasives increased 10% in quantity and 17% in value. A new abrasive, fused aluminum zirconium oxide, was added to the canvass by the Bureau of Mines for 1973.

FOREIGN TRADE

Imports of abrasive materials were 28% more in value than in 1972, and exports plus reexports increased 24%. Net imports, the excess of imports over exports and reexports, were $24.2 million, a 55% increase over 1972 net imports. The volume as well as the unit value of nearly all abrasive materials imported increased.

The trade in industrial diamond continued to have a major influence on the total value. Industrial diamond imports totaled 19.2 million carats valued at $65.6 million, an increase of 27% in quantity, and 25% in value above those of 1972. The exports of industrial diamond amounted to 10.5 million carats, an increase of 19%, and the value was $29.4 million, an increase of 22%. Reexports of industrial diamond amounted to 4.5 million carats, a decrease of 1%, and the value was $29.2 million, an increase of 10%. Dust and powder accounted for 95% of the carats and 85% of the value of exports, whereas other diamond, or stones, accounted for 80% of the carats and 88% of the value of reexports of industrial diamond.

[1] Physical scientist, Division of Nonmetallic Minerals—Mineral Supply.

Table 1.—Salient abrasive statistics in the United States

Kind	1969	1970	1971	1972	1973
Natural abrasives (domestic) sold or used by producers:					
Tripoli (crude) short tons	84,673	68,105	75,134	87,864	101,519
Value thousands	$734	$520	$569	$797	$929
Special silica-stone products [1] short tons	3,311	3,134	2,349	3,241	3,466
Value thousands	$600	$665	$563	$670	$677
Garnet short tons	20,458	18,837	18,984	18,916	22,772
Value thousands	$1,874	$1,936	$1,934	$1,957	$2,380
Emery short tons	W	W	1,586	2,883	2,884
Value thousands	W	W	W	W	W
Artificial abrasives [2] short tons	608,622	561,107	472,299	584,680	[3] 645,813
Value thousands	$92,589	$85,772	$79,027	$92,958	[3] $108,808
Foreign trade (natural and artificial abrasives)					
Exports (value) do	$70,687	$64,338	$60,685	$64,219	$82,969
Reexports (value) do	$20,373	$28,085	$21,711	$26,746	$29,413
Imports for consumption (value) do	$100,748	$96,467	$89,085	$106,512	$136,536

W Withheld to avoid disclosing individual company confidential data.
[1] Includes grinding pebbles, grindstones, oilstones, tube-mill liners, and whetstones.
[2] Production of silicon carbide and aluminum oxide (United States and Canada); shipments of metallic abrasives (United States).
[3] Includes production of aluminum zirconium oxide (United States and Canada).

Table 2.—U.S. exports of abrasive materials, by kind

(Thousands)

Kind	1972		1973	
	Quantity	Value	Quantity	Value
NATURAL ABRASIVES				
Dust and powder of natural and synthetic precious or semiprecious stones, including diamond dust and powder ____carats__	8,263	$21,986	9,928	$25,071
Crushing bort, except dust and powder ____do____	55	305	40	138
Industrial diamond ____do____	484	1,899	516	4,208
Emery, natural corundum, and other natural abrasives, n.e.c ____pounds__	21,850	2,797	35,625	3,979
MANUFACTURED ABRASIVES				
Artificial corundum (fused aluminum oxide) ____do____	36,386	7,251	59,157	11,470
Silicon carbide, crude or in grains ____do____	10,014	2,194	15,445	3,413
Carbide abrasives, n.e.c ____do____	1,963	4,157	1,964	4,006
Grinding and polishing wheels and stones:				
Diamond ____carats__	554	3,073	746	4,223
Pulpstones ____pounds__	2,185	702	2,450	833
Polishing stones, whetstones, oilstones, hones, and similar stones ____do____	873	981	787	1,050
Wheels and stones, n.e.c ____do____	4,361	8,238	5,204	9,776
Abrasive paper and cloth, coated with natural or artificial abrasive materials ____reams__	322	8,240	360	12,067
Coated abrasives, n.e.c ____	NA	2,396	NA	2,735
Total ____	XX	64,219	XX	82,969

NA Not available. XX Not applicable.

Table 3.—U.S. reexports of abrasive materials, by kind

(Thousands)

Kind	1972		1973	
	Quantity	Value	Quantity	Value
NATURAL ABRASIVES				
Dust and powder of natural and synthetic precious or semiprecious stones, including diamond dust and powder carats__	336	$790	488	$1,206
Crushing bort except dust and powder ____do____	329	1,925	418	2,372
Industrial diamond ____do____	3,852	23,867	3,579	25,596
Emery, natural corundum, and other natural abrasives, n.e.c ____pounds__	295	60	167	39
MANUFACTURED ABRASIVES				
Carbide abrasives ____do____	--	--	(1)	9
Grinding and polishing wheels and stones:				
Diamond ____carats__	1	10	1	9
Polishing stones, whetstones, oilstones, hones, and similar stones ____pounds__	--	--	1	3
Wheels and stones, n.e.c ____do____	35	40	103	132
Abrasive paper and cloth, coated with natural or artificial abrasive materials ____reams__	5	37	(1)	(1)
Coated abrasives, n.e.c ____	NA	17	NA	47
Total ____	XX	26,746	XX	29,413

NA Not available. XX Not applicable.
[1] Less than ½ unit.

Table 4.—U.S. imports for consumption of abrasive materials (natural and artificial), by kind

(Thousands)

Kind	1972 Quantity	1972 Value	1973 Quantity	1973 Value
Corundum, crude ---short tons--	(1)	$2	1	$34
Emery, flint, rottenstone, and tripoli, crude or crushed do----	4	222	13	403
Silicon carbide, crude ---do----	105	15,053	113	16,762
Aluminum oxide, crude ---do----	173	22,308	188	29,190
Other crude artificial abrasives ---do----	(1)	107	1	210
Abrasives, ground grains, pulverized or refined:				
Silicon carbide ---do----	2	906	4	1,510
Aluminum oxide ---do----	7	2,154	7	2,156
Emery, corundum, flint, garnet, and other including artificial abrasives ---do----	1	188	(1)	166
Papers, cloths, and other materials wholly or partly coated with natural or artificial abrasives ---do----	(2)	9,944	(2)	14,682
Hones, whetstones, oilstones, and polishing stones number--	380	109	367	118
Abrasives wheels and millstones:				
Burrstones manufactured or bound up into millstones ---short tons--	(1)	11	(1)	4
Solid natural stone wheels ---number--	1	10	9	17
Diamond ---do----	53	562	93	1,037
Other ---	(2)	1,789	(2)	3,698
Articles not especially provided for:				
Emery or garnet ---	(2)	24	(2)	51
Natural corundum or artificial abrasive materials--	(2)	183	(2)	267
Other ---	(2)	133	(2)	242
Diamond:				
Diamond dies ---number--	9	188	13	395
Crushing bort ---carats--	590	1,385	74	166
Other industrial diamond ---do----	4,506	27,343	5,555	34,378
Miners' diamond ---do----	1,024	4,712	973	4,650
Dust and powder ---do----	9,014	19,179	12,552	26,400
Total ---	XX	106,512	XX	136,536

XX Not applicable.
[1] Less than ½ unit.
[2] Quantity not reported.

TRIPOLI

Fine-grained, porous, silica materials are discussed as a group because they have similar properties and end uses. Commercially the term "tripoli" is applied to material from Arkansas, Missouri, and Oklahoma; and the term "amorphous" or "soft" silica is applied to the material from the Southern Illinois area. Rottenstone mined in Pennsylvania is more earthy but its properties render it suitable for end uses similar to those of tripoli and amorphous silica. Production of crude tripoli (table 1) increased 16% in quantity and 17% in value. Processed tripoli (table 5) for abrasive use was 62% of the total, and material for filler use was 36%, compared with 63% and 35%, respectively, in 1972.

Tripoli producers in 1973 were Malvern Minerals Co., Garland County, Ark., which produced crude and finished material, and The Carborundum Co., which produced crude in Ottawa County, Okla., and finished material in Newton County, Mo. Amorphous silica producers were Illinois Minerals Co. and Tammsco, Inc., both in Alexander County, Ill. Keystone Filler and Manufacturing Co., in Lycoming County, Pa., mined and processed rottenstone. The largest amounts of amorphous silica and rottenstone were used for abrasive purposes; there was minor use as a filler.

Prices quoted in Engineering and Mining Journal, December 1973 for tripoli and amorphous silica were as follows:

Tripoli, paper bags, carload lots, f.o.b., cents per pound:

White, Elco, Ill.:	
Air floated through 200-mesh	1.35
Rose and cream, Seneca, Mo. and Rogers, Ark.:	
Once ground	2.90
Double ground	2.90
Air float	3.15

Amorphous silica, bags, f.o.b., dollars per ton:

Elco, Ill.:	
Through 200 mesh, 90 to 95%	27
Through 200 mesh, 96 to 99%	28
Through 325 mesh, 90 to 95%	29
Through 325 mesh, 96 to 98%	31.50
Through 325 mesh, 98 to 99.4%	32.50
Through 325 mesh, 99.5%	46.50
Through 400 mesh, 99.9%	68
Below 15 microns, 99%	75
Below 10 microns, 99%	95
Dierks, Ark.:	
200 mesh	30
325 mesh	40

Table 5.—Processed tripoli[1] sold or used by producers in the United States, by use[2]

Kind	1969	1970	1971	1972	1973
Abrasives short tons	50,337	41,703	44,899	47,321	55,420
Value thousands	$2,013	$1,583	$1,692	$1,918	$2,233
Filler short tons	14,352	18,093	20,457	25,973	32,407
Value thousands	$413	$545	$681	$747	$1,158
Other short tons	5,487	1,134	1,327	1,584	2,105
Value thousands	$157	$28	$32	$43	$62
Total short tons	70,176	60,930	66,683	74,878	89,932
Value[3] thousands	$2,584	$2,156	$2,406	$2,807	$3,453

[1] Includes amorphous silica and Pennsylvania rottenstone.
[2] Partly estimated.
[3] Data may not add to totals shown because of independent rounding.

SPECIAL SILICA STONE PRODUCTS

Special silica stone products include the following: Oilstones from Arkansas, whetstones from Arkansas and Indiana, grindstones from Ohio, grinding pebbles and deburring media from Minnesota and Wisconsin, and tube-mill liners from Minnesota. Production increased overall in both quantity and value.

Novaculite for oilstones, all from operations in Garland County, Ark., was produced by John O. Glassford, Cleve Milroy, M. V. Smith, and Norton Pike Division of Norton Co. Whetstones were produced by Arkansas Abrasives, Inc., and Hiram A. Smith Whetstone Co., both in Garland County, Ark., and by Hindostan Whetstone Co. in Orange County, Ind. Cleveland Quarries Co. produced grindstones at its Amherst quarry, Amherst County, Ohio. Jasper Stone Co. produced grinding pebbles and tube-mill liners from its quarry in Jasper County, Minn. Baraboo Quartzite Co., Inc., produced deburring media at its quarry in Sauk County, Wis.

Table 6.—Special silica-stone products sold or used in the United States[1]

Year	Quantity (Short tons)	Value (Thousands)
1969	3,311	$600
1970	3,134	665
1971	2,349	563
1972	3,241	670
1973	3,466	677

[1] Includes grinding pebbles, grindstones, oilstones, tube-mill liners, and whetstones.

NATURAL SILICATE ABRASIVES

Garnet.—Sales of domestic garnet increased 20% in quantity and 22% in value. Normal processing included crushing, grinding, and screening to produce specified particle sizes and grits. However, further processing was performed on some material to meet specifications for special end uses. There were four active producers—two in New York and two in Idaho. Barton Mines Corp., Warren County, N.Y., the largest producer, processed the garnet for use in coated abrasives, glass grinding and polishing, and metal lapping. Also in New York, Interpace Corp., Essex County, recovered garnet as a byproduct of wollastonite ore. Idaho Garnet Abrasive Co. and Emerald

Creek Garnet Milling Co. produced garnet from placer deposits in Benewah County, Idaho. The latter three producers reported the use of garnet for a variety of purposes, such as sandblasting, water filtration, nonskid paints, and miscellaneous abrasive applications.

Prices for New York garnet, f.o.b. North Creek, N.Y., 2,000-pound release, in 330 to 370 pound containers; in cents per pound were as follows:

Untreated for manufacturing of coated abrasives:

Grades 16 through 36	18
Grades 40 through 220	20
Grades 240 through 280	28
Grades 320 through 600	25

Untreated for technical grinding and lapping:

Mesh sizes 20 to 240	15
Mesh sizes 280 to 360	20
Micron sizes 27 to 23	22
Micron sizes 20 to 8	25
Micron sizes 6 to 5	19
Micron sizes 4 to 2	34

Prices for Idaho garnet, f.o.b. Seattle, ranged from 5.5 to 9 cents per pound.

Table 7.—Abrasive garnet sold or used by producers in the United States

Year	Quantity (Short tons)	Value (Thousands)
1969	20,458	$1,874
1970	18,837	1,936
1971	18,984	1,934
1972	18,916	1,957
1973	22,772	2,380

NATURAL ALUMINA ABRASIVES

Corundum.—Domestic production of abrasive-grade corundum on a commercial scale was last reported in 1918. In recent years nearly all of the corundum used by domestic industry was imported from Southern Rhodesia, but this trade was halted by the sanctions imposed in 1968 by the United Nations. The Office of Emergency Preparedness in 1969 dropped corundum from the list of strategic and critical materials for stockpiling. In 1971, Bendix Abrasives Division, Westfield Facility, of Westfield, Mass., acquired 1,964 short tons of corundum from Government stockpiles after Congressional approval was granted. Domestic industry completed the consumption of accumulated stocks in 1973.

Emery.—Domestic production of emery in 1973 was by two producers, De Luca Emery Mine, Inc., near Peekskill in Westchester County, N. Y., and Oregon Emery Co. near Sweethome in Linn County, Oreg. Data on value of production were withheld to avoid disclosing individual company confidential data. The quantity of production, 2,884 tons, was slightly more than that of 1972. Emery use was mostly in aggregate for heavy-duty nonslip floors, pavements, and stair treads. In lesser amounts it was used in coated abrasives and tumbling abrasives.

World production data, in short tons, are mainly for two countries. In 1971, production of emery in Turkey was 87,353 tons; and in 1972, production was 87,998 tons. Production of emery in Greece was estimated to be 7,716 tons for each year, 1971 and 1972.

Table 8.—Natural corundum: World production by country

(Short tons)

Country [1]	1971	1972	1973 [p]
India	[r] 351	422	[e] 440
Kenya	(2)	(2)	--
Malagasy Republic	1	3	NA
Malawi	(3)	NA	NA
South Africa, Republic of	266	324	[e] 300
U.S.S.R.[e]	[r] 7,165	7,700	7,700
Total	[r] 7,783	8,449	NA

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] In addition to the countries listed, Southern Rhodesia may have continued to produce natural corundum at a significant level (several thousand tons annually), but available information is inadequate to make reliable estimates of output levels.

[2] Revised to zero.

[3] Less than ½ unit.

INDUSTRIAL DIAMOND

Domestic production of synthetic industrial diamond in 1973 was estimated to be 17 million carats, up 2 million carats from that of 1972. Secondary production comprising salvage from used diamond tools and from wet and dry diamond-containing wastes was estimated to be 2 million carats.

The Government stockpile inventory as of December 31, 1973, was 38.8 million carats of crushing bort and 22.6 million carats of stones. The objectives for both categories were reduced to zero and the inventories were considered excess. Prior enabling legislation for disposal was for bort, 15.1 million carats, and for stones, 2.6 million carats. Legislation was requested for disposal of the remaining 23.7 million carats of bort; and, 20.0 million carats of stones. The inventory of small diamond dies was 25,473 of which the objective was 7,900, and 17,573 were excess.

Exports and reexports of industrial diamond dust and powder, which included synthetics, were 10.4 million carats valued at $26.3 million. Crushing bort, except dust and powder, exported amounted to 0.5 million carats valued at $2.5 million. Exports and reexports of stones were 4.1 million carats valued at $29.8 million. The total of exports and reexports of dust and powder, bort, and stones was 15 million carats valued at $58.6 million.

Imports of industrial diamond in 1973 increased 27% in number of carats and 25% in value over 1972 figures. Receipts from Ireland were 9.4 million carats valued at $21.1 million, increases of 26% in quantity and 18% in value, respectively, in 1973 over the 1972 figures. The share of imports from Ireland was 49% of quantity and 32% of value. Of the industrial diamond listed as powder or dust, synthetic diamond was 5.2 million carats valued at $10.6 million, and natural diamond was 7.3 million carats valued at $15.8 million.

Table 9.—U.S. imports for consumption of industrial diamond (excluding diamond dies)

(Thousand carats and thousand dollars)

Year	Quantity	Value
1971	12,910	46,023
1972	15,134	52,619
1973	19,154	65,594

WORLD REVIEW

Angola.—Exports of the Companhia de Diamantes de Angola (DIAMANG), Angola's only diamond producer in 1972, dropped by 6% to 2,199,860 carats during 1972.[2] All diamond exports are destined for metropolitan Portugal. However, export income rose by 4% to $63.4 million in 1972, as the percentage of gem stones increased. The percentage of gems was expected to increase to about 70% in 1973. Diamonds accounted for 11% of Angola's export income in 1972. Several promising deposits of kimberlite were found in 1972 and 1973 by the Consorcio de Diamantes de Angola (CONDIAMA), the consortium of DIAMANG and De Beers Consolidated Mines Ltd.'s interests which inherited all but 50,000 square kilometers of DIAMANG's former concession area. None of the three small firms prospecting for diamond in the coastal area had announced any significant finds during the past year.

Botswana.—The Government and DeBeers Botswana Mining Co. (Pty) Ltd. discussed development of the Dk 1 kimberlite pipe 25 miles southeast of the existing Orapa mine, which currently produces 2.4 million carats worth about $30 million a year.[3] Dk 1 is an extensive primary diamondiferous deposit which can probably be worked initially as an open pit and could be operating by 1975.

Central African Republic.—Cominco, Ltd., of Canada, held majority interest in a new company, Société Centrafricaine d'Exploitation Diamantifère (SCED), formed with Diamond Distributors Inc. of New York to conduct diamond mining and exploration in the Central African Republic.[4] The new project resulted from meetings with Government officials in Bangui, the capital. Cominco will manage the company and provide technical direction for field work. Diamond Distributors will market the production.

[2] U.S. Bureau of Mines. Angola. Developments and Outlook for Angola's Minerals Industries. Nonmetallic Minerals. Mineral Trade Notes, v. 70, No. 8, August 1973, p. 9.

[3] Engineering and Mining Journal. In Africa, Botswana. V. 174, No. 12, December 1973, p. 127.

[4] The Northern Miner. Cominco to Mine Diamonds in Central African Republic. V. 59, No. 37, Nov. 29, 1973, p. 32.

Table 10.—U.S. imports for consumption of industrial diamond, by country

(Thousand carats and thousand dollars)

Country	Crushing bort (including all types of bort suitable for crushing)				Other industrial diamond (including glazers' and engravers' diamond, unset)				Miners' diamond				Powder and dust			
	1972		1973		1972		1973		1972		1973		1972		1973	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quan. tity	Value	Quantity	Value
Australia	--	--	--	--	5	58	1	17	43	189	--	--	--	--	--	--
Belgium-Luxembourg	231	489	19	38	1,475	6,131	1,689	7,714	2	11	5	13	110	192	315	551
Belize	--	--	--	--	--	--	--	--	--	--	4	14	--	--	--	--
Brazil	--	--	(1)	(1)	2	21	4	59	--	--	--	--	--	--	--	--
British West Africa	--	--	--	--	14	74	7	40	2	11	11	46	--	--	--	--
Canada	--	--	3	9	38	137	59	369	7	26	2	18	319	311	312	253
Central African Republic	--	--	--	--	6	195	2	4	--	--	--	--	--	--	--	--
Congo (Brazzaville)	--	--	--	--	42	123	109	261	--	--	--	--	--	--	13	30
Cyprus	--	--	--	--	7	17	--	--	--	--	6	16	--	--	--	--
France	--	--	--	--	8	310	21	700	--	--	--	--	2	3	1	1
Germany, West	--	--	(1)	1	5	45	3	32	--	--	1	3	30	56	(1)	(1)
Ghana	2	7	--	--	76	380	54	349	6	30	9	45	10	5	4	8
Ireland	--	--	20	34	14	34	25	137	583	2,739	20	34	6,869	15,155	9,364	20,914
Israel	--	--	--	--	16	320	29	514	2	7	(1)	(1)	8	17	4	19
Japan	--	--	--	--	111	2,162	81	1,429	1	2	60	115	808	1,685	703	1,398
Liberia	--	--	--	--	(1)	(1)	10	58	--	--	--	--	--	--	--	--
Mauritania	--	--	--	--	--	--	9	14	--	--	--	--	6	11	58	96
Netherlands	29	90	1	2	328	2,894	311	2,994	(1)	1	--	--	70	144	89	232
Sierra Leone	--	--	--	--	(1)	13	1	100	--	--	--	--	(1)	1	1	1
South Africa, Republic of	127	320	11	27	1,143	7,541	1,651	10,176	353	1,559	838	4,201	115	244	125	190
Switzerland	12	26	2	8	13	146	3	36	(1)	(1)	3	13	115	137	110	175
U.S.S.R	--	--	--	--	--	--	20	31	--	--	--	--	116	183	724	1,060
United Kingdom	88	225	--	--	1,040	5,717	1,409	8,969	14	58	2	9	345	816	564	1,054
Venezuela	4	9	--	--	2	35	2	13	8	64	6	108	--	--	--	--
Western Portuguese Africa, n.e.c	--	--	--	--	85	719	29	288	--	--	--	--	--	--	1	1
Zaire	97	219	18	47	75	r 218	13	33	(1)	1	5	13	84	212	123	341
Other	--	--	--	--	1	53	13	41	3	14	1	2	7	7	41	76
Total	590	1,385	74	166	4,506	27,343	5,555	34,378	1,024	4,712	973	4,650	9,014	19,179	12,552	26,400

r Revised.
1 Less than ½ unit.

China, People's Republic of.—The New China News Agency reported the production of synthetic industrial diamond by subjecting carbon substances to "dynamic high pressure," an explosive process. It was accomplished by the Institute of Physics of the Chinese Academy of Sciences in cooperation with the Peking Grinding-Wheel Works.[5] China became independent of other countries for industrial diamonds in fine sizes by this accomplishment.

Lesotho.—The Lesotho National Development Corp. (LNDC) continued efforts to interest commercial developers in diamond mining areas.[6] Rio Tinto Zinc Corp. (RTZ) abandoned the Letseng-la-Terai diamond pipe in the Mokhotlong District in 1972. The LNDC granted De Beers permission in July to conduct a 6-month evaluation of the Letseng pipe. Newmont Mining Corp. cancelled further exploration and development of the Kao pipe in Butha Buthe District early in 1973 after investing $5.6 million. Nord Resources Corp. of the United States and the Anglo American Corp. of South Africa Ltd. indicated an interest in the areas abandoned by RTZ and Newmont.

Sierra Leone.—Although diamond production in 1972 decreased from that of 1971, higher world diamond prices in 1972 resulted in greater revenue to Sierra Leone. The first 6 months of 1973 were well ahead of the comparable period of 1972 in both the number of carats produced and in value. Diamond exports continued to be the backbone of the Sierra Leone economy.

South Africa, Republic of.—The Central Selling Organization of the De Beers group announced record diamond sales of R920.7 million in 1973, an increase of 40.5% over sales in 1972.[7] Following the U.S. dollar devaluation, rand price increases were announced in succession thus: February, 11%; March, 7%; May, a selective 10% for certain categories of larger gem stones; and August, 10.2%. No breakdown was given for industrial or for gem stones but the price increases were applied to industrial stones as well as to gem stones.

U.S.S.R.—Natural diamond production in Siberia was estimated to exceed that of the Republic of South Africa. However, the proportion of gem stones actually mined in Siberia was less than that of South Africa making the value of South African production greater.

Zaire.—Although Zaire remains the number one producer of diamond, the proportion of industrial diamond (98% in Zaire) reduces the value of production there to a low rank.

TECHNOLOGY

Theories to explain the occurrences or formations of diamond pipes continued to interest scientists. Chemical analyses of minerals in the rock of the pipes, called kimberlite, and of diamond, have yielded new evidence about the eruptions.[8] Garnet peridotite, which is composed of garnet, enstatite, diopside, and olivine, is typically found in kimberlite. The amount of mixing of the materials or minerals indicates the depth, or pressure, and the temperature of formation. Analyses of South African kimberlite samples indicated formation at depths from 145,000 yards to 200,000 yards and temperatures from 950° C to 1370° C. From the depths, water and liquefied gases in the earth's mantle forced a passage upwards. The fluid mixture of water and liquefied gases moved slowly at first, but as the fluid neared the surface, it was vaporized by reduced pressure. The resulting expansion drove the eruption with increased velocity, creating a shape much like the crater left by a meteor. Erosion destroyed the crater, leaving behind a column of cooled and hardened material as a pipe in the earth's crust. Kimberlite pipes have pierced coal seams without buring the coal. The rapid decompression, according to the expanding gas theory, would have had a tremendous chilling effect.

British diamond lapping specialists marketed microscopic-sized gelatin capsules containing wetted diamond particles.[9] Microencapsulation is designed to provide individual abrasive particles at the workface free from agglomeration and surrounded and wetted by lubricant in a pressure-rupturable wall. Potentially toxic or carcinogenic materials needed to assist the abrasive action are controlled and present no health hazards.

Alternative abrasive materials such as natural or synthetic ruby, sapphire, fused

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[5] New China News Agency (International Services in English; Peiping). Oct. 5, 1973.
[6] Bureau of Mines. Mineral Trade Notes, v. 70, No. 9, September 1973, p. 5.
[7] Mining Journal. Diamonds, CSO Sales Sparkle. V. 282, No. 7222, Jan. 18, 1974, p. 36.
[8] Chemistry. Diamond Pipes. V. 46, No. 5, May 1973, pp. 23–24.
[9] Industrial Diamond Review. Another Lapping Revolution on the Way? January 1973, p. 14.

Table 11.—Diamond (natural): World production by country[1]

(Thousand carats)

Country	1971			1972			1973 p		
	Gem	Indus-trial	Total	Gem	Indus-trial	Total	Gem	Indus-trial	Total
Africa:									
Angola	1,810	603	2,413	1,616	539	2,155	1,594	531	2,125
Botswana	82	740	822	360	2,043	2,403	362	2,054	2,416
Central African Republic	r 304	r 164	r 468	346	178	524	251	129	380
Ghana	256	2,306	2,562	266	2,393	2,659	232	2,085	2,317
Guinea [e]	22	52	74	25	55	80	25	55	80
Ivory Coast	130	196	326	134	200	334	120	180	300
Lesotho [2]	1	6	7	1	8	9	1	9	e 10
Liberia	[3] 532	[3] 277	[3] 809	[3] 414	[3] 350	[3] 764	450	370	e 820
Sierra Leone	r 778	r 1,168	r 1,946	720	1,080	1,800	[4] 670	[4] 1,000	e [4] 1,670
South Africa, Republic of:									
Premier mine	609	1,828	2,437	613	1,841	2,454	625	1,876	2,501
Other de Beers Company [5]	2,162	1,769	3,931	2,289	1,872	4,161	2,368	1,938	4,306
Other	398	265	663	468	312	780	455	303	758
Total	3,169	3,862	7,031	3,370	4,025	7,395	3,448	4,117	7,565
South West Africa, Territory of	1,566	82	1,648	1,516	80	1,596	1,520	80	1,600
Tanzania	419	418	837	[4] 326	[4] 325	[4] 651	290	290	e 580
Zaire	r 1,274	r 11,469	r 12,743	1,339	12,051	13,390	1,294	11,646	12,940
Other areas:									
Brazil [e]	150	150	300	155	155	310	160	160	320
Guyana	19	29	48	20	29	49	21	31	e 52
India	16	3	19	17	3	20	18	3	21
Indonesia [e]	12	3	15	12	3	15	12	3	15
U.S.S.R. [e]	1,800	7,000	8,800	1,850	7,350	9,200	1,900	7,600	9,500
Venezuela	114	385	499	141	315	456	241	537	778
World total	r 12,454	r 28,913	r 41,367	12,628	31,182	43,810	12,609	30,880	43,489

e Estimate. p Preliminary. r Revised.

[1] Total (gem plus industrial) diamond output for each country is actually reported except where indicated to be an estimate by footnote. In contrast, the detailed separate reporting of gem diamond and industrial diamond represents Bureau of Mines estimates in the case of all countries except Lesotho (1971 and 1972), Liberia (1971 and 1972), and Venezuela (1971 and 1972), where sources give both total output and detail. The estimated distribution of total output between gem and industrial diamond is conjectural in the case of a number of countries, based on unofficial information of varying reliability.

[2] Exports of diamond originating in Lesotho; excludes stones imported for cutting and subsequently reexported.

[3] Exports for year ending August 31 of that stated.

[4] Exports.

[5] All company output from the Republic of South Africa except for that from the Premier mine; also excludes company output from the Territory of South West Africa and from Botswana.

aluminum oxide, silicon carbide, cubic boron nitride, and others can be used in conjunction with lubricants and chemical agents. As an alternate to gelatin, polyethylene oxide, styrene maleic anhydride, cellulose acetate phthalate and numerous others may be used as wall materials.

Polished 0.2-carat natural diamonds were shaped in the form of precision gaging points to monitor coin thickness at the Bavarian main mint in Munich, West Germany.[10] The increasing use of vending machines required tighter tolerances on the dimensions, weights, and composition of coins to counteract the growing use of low value substitutes for official coins. The diamond measuring tips improved the consistency in dimensional accuracy.

About 230 tons of diamond have been mined in history and to get this quantity, miners have had to handle 5 billion tons of rock, sand, and gravel for which the diamond content was only one part in 20 million. Of this total of 230 tons, 100 tons of diamond has been produced between 1960 and 1972. The new techniques, which have been added to already highly developed mining, quarrying, earth moving, and sophisticated recovery processes, were described in a well-illustrated publication.[11]

Abstracts relative to properties of diamond, hard materials, machines, and patents were published monthly in the periodical Industrial Diamond Review.

Each monthly issue, January to December 1973, contained from 14 to 18 pages of abstracts and patent information.

ARTIFICIAL ABRASIVES

Crude fused aluminum oxide was produced in 1973 by five firms in the United States and in Canada. The Carborundum Co., Norton Co., and General Abrasive Co., Inc., each operated plants in both countries. The Exolon Co. and Simonds Canada Abrasive Co., Ltd., operated plants in Canada. Output of white, high-purity material was 28,146 tons and of regular grade was 168,159 tons. Twelve percent of the combined output of white and regular was used for nonabrasive applications, principally in the manufacture of refractories. Output was 69% of the rated capacity of the furnaces assigned to fused aluminum oxide.

Crude fused alumina zirconia abrasive was produced in 1973 by four firms in the United States and in Canada. The Carborundum Co., Exolon Co., General Abrasive Co., Inc., and Norton Co. reported production from their plants for the first time. All production was reportedly used for abrasive applications. Output was 82% of the rated capacity of the furnaces marked for production of fused alumina zirconia.

Silicon carbide was produced in 1973 by six firms in the United States and Canada. The Carborundum Co. operated plants in both countries and Electro-Refractories & Abrasives Ltd., the Exolon Co., Norton Co., and General Abrasive Co., Inc. operated in Canada; all produced crude for abrasive, refractory, and miscellaneous uses. Satellite Alloy Corp. operated in the United States and produced crude for nonabrasive applications. Production by the six firms was 86% of capacity and 48% was reportedly used for abrasive applications. Nonabrasive use was 52% of the output and was mostly for refractory and metallurgical applications.

In the Stockpile Report to the Congress by the General Services Administration crude fused aluminum oxide in calendar year 1973 was reduced in inventory by 61,038 tons to 312,431 tons as of December 31; aluminum oxide abrasive grain was unchanged at 50,905 tons, and silicon carbide crude was unchanged at 196,453.

The manufacture of metallic abrasives in 1973 increased 6% in quantity and 21% in value. Of the total quantity sold or used, steel shot and grit comprised 78%; chilled iron shot and grit, 17%; annealed iron shot and grit, 4%. Other metallic abrasives sold or used included aluminum, copper, stainless steel, and zinc. Production from Ohio was 32% of the total quantity, the highest of the producing States. Michigan, Indiana, and Pennsylvania followed in rank of quantity and their combined output was 61% of the total. The remaining 7% was produced at plants in Alabama, New York, and Connecticut. Three companies reworked ma-

[10] Industrial Diamond Review. Diamonds Help Keep the Deutschmark Stable. July 1973, pp. 266–268.

[11] Linari-Linholm, A. A. Occurrence, Mining and Recovery of Diamonds. De Beers Consolidated Mines Ltd., Kenion Press Ltd., England, 1973, pp. 1–40.

terial for other producers: Copperweld Steel Co. of Glassport, Pa.; Industeel Corp. of Pittsburgh, Pa.; and Kohler Co. of Sheboygan, Wis.

TECHNOLOGY

Vibratory or tumbling barrels may be used for finish grinding or polishing of objects. Media are the abrasive materials used to deburr, descale, grind, and burnish. Compounds enhance these actions, as well as provide other operational benefits. The fundamentals of media selection and compounds, what they are, what they do, and how to use them were described.[12]

As in previous years, the number of patents describing the use of abrasive materials in abrasive and refractory products was large, but most of the patents described improvements in the materials, products, and machines. Trade journals and magazines furnished many articles describing new processes, new products, and new applications.

A need exists for education in the technology of metalworking processes and products. Many abrasive materials producers sponsor training in the use of abrasives for personnel of consuming industries to supplement the courses offered by technical schools. An example was described.[13]

[12] Brandt, J. N. Fundamentals of Media Selection. Abrasive Eng., November December 1973, pp. 16–21.

[13] Abrasive Engineering. Practical Borazon Education. November–December 1973, p. 23.

Table 12.—Crude artificial abrasives produced in the United States and Canada

(Thousand short tons and thousand dollars)

Kind	1969	1970	1971	1972	1973
Silicon carbide [1]	161	167	130	166	162
Value	23,945	24,038	21,123	24,690	25,471
Aluminum oxide (abrasive grade)[1]	217	195	149	184	196
Value	31,276	27,402	24,514	28,590	27,339
Aluminum zirconium oxide	--	--	--	--	22
Value	--	--	--	--	6,223
Metallic abrasives [2]	230	199	193	235	266
Value	37,369	34,332	33,390	39,678	49,775
Total [3]	609	561	472	585	646
Value [3]	92,589	85,772	79,027	92,958	108,808

[1] Figures include material used for refractories and other nonabrasive purposes.
[2] Shipments for U.S. plants only.
[3] Data may not add to totals shown because of independent rounding.

Table 13.—Production, shipments, and annual capacities of metallic abrasives in the United States, by product

Year and product	Manufactured		Sold or used		Annual capacity [1]
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	
1972:					
Chilled iron shot and grit	31,531	$4,048	37,300	$4,679	129,000
Annealed iron shot and grit	18,615	2,110	20,868	2,713	(2)
Steel shot and grit	175,938	25,860	175,799	31,844	228,650
Other [3]	766	356	833	442	4,500
Total	226,850	32,374	234,800	39,678	362,150
1973:					
Chilled iron shot and grit	35,024	3,992	45,196	6,295	61,400
Annealed iron shot and grit	7,739	712	9,984	1,405	29,480
Steel shot and grit	194,580	33,679	206,918	41,104	243,370
Other [3]	3,575	903	3,792	972	10,760
Total	240,918	39,286	265,890	49,776	345,010

[1] The total quantity of the various types of metallic abrasives that a plant could have produced during the year, working three 8-hour shifts per day, 7 days per week, allowing for usual interruptions, and assuming adequate fuel, labor, and transportation.
[3] Included in capacity of chilled iron shot and grit.
[3] Includes cut wire shot.

Table 14.—Stocks of crude artificial abrasives and capacity of manufacturing plants in the United States and Canada

(Thousand short tons)

Year	Silicon carbide		Aluminum oxide		Aluminum zirconium oxide	
	Stocks December 31	Annual capacity	Stocks December 31	Annual capacity	Stocks December 31	Annual capacity
1969	9.1	181.7	33.2	358.2	--	--
1970	18.7	179.1	30.8	359.2	--	--
1971	14.2	198.1	25.6	293.2	--	--
1972	5.2	195.7	16.3	291.2	--	--
1973	5.4	189.1	19.3	284.6	0.7	26.9

Producers of metallic abrasives were as follows:

Company	Plants
Abbott Ball Co	Hartford, Conn.
Abrasive Materials, Inc	Hillsdale, Mich.
Abrasive Metals Co	Pittsburgh, Pa.
The Carborundum Co	Butler, Pa.
Cleveland Metal Abrasive Co.:	
	Birmingham, Ala.
	Howell, Mich.
	Springville, N.Y.
	Cleveland, Ohio
	Toledo, Ohio
Durasteel Abrasive Co	Pittsburgh, Pa.
Ervin Industries	Pittsburgh, Pa.
Globe Steel Abrasive Co	Adrian, Mich.
Metal Blast, Inc	Mansfield, Ohio
National Metal Abrasive Co.	Cleveland, Ohio
Pellets, Inc	Do.
Steel Abrasives, Inc	Tonawanda, N.Y.
Wheelabrator-Frye ,Inc	Hamilton, Ohio
	Mishawaka, Ind.

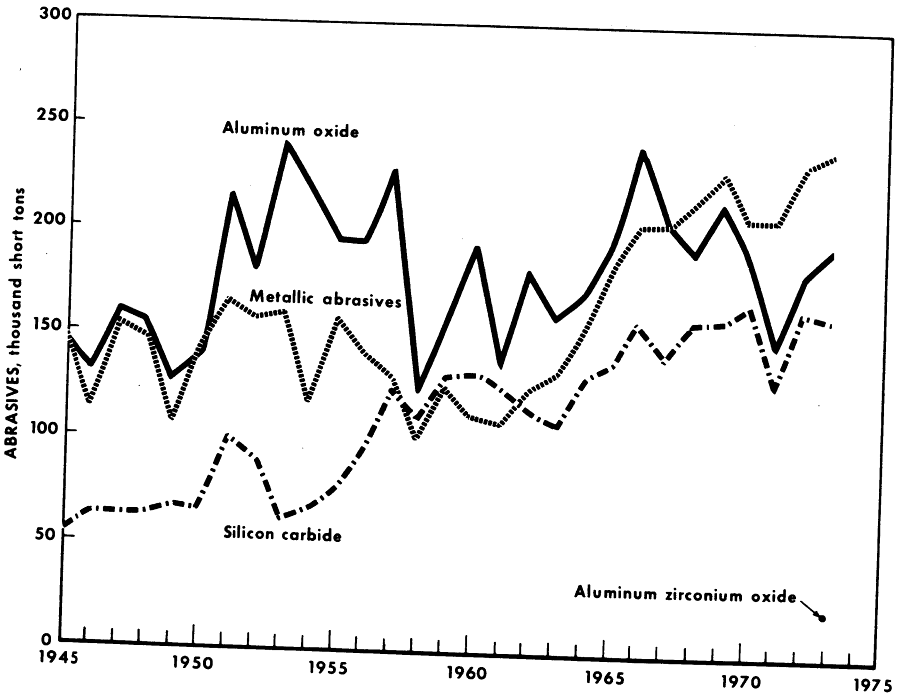

Figure 1.—Artificial abrasives production.

Aluminum

By John W. Stamper [1]

Estimated world demand for primary aluminum surged ahead by about 12% over that of the previous year. Shortages of electric energy held output growth significantly below potential in the United States and Japan and caused a decline in production in India. As a result, world production of primary aluminum was up only 10%, and although sales from government-held stocks in the United States helped avert a drastic shortage in that country, supply was tight in all major consuming areas during most of the year. Some 10% to 15% of the electric energy used to produce primary aluminum in many countries was believed to be provided by oil-fired thermal generating plants and the sharp increase in world oil prices during the latter part of 1973 compounded energy supply problems and accelerated industry interest in locating aluminum plants close to sources of low-cost thermal or hydroelectric power, most of which are outside the major consuming areas.

Legislation and Government Programs.—During 1973, 698,800 short tons of primary aluminum was shipped from government inventories. The total quantity shipped by the government from December 1965, when the disposal program was initially implemented, to the end of 1973, was 1,322,298 tons. Late in December 1972, the stockpile objective for aluminum was reduced from 450,000 tons to none and Public Law 93-220, which authorized the disposal of the 450,000 tons of primary aluminum held in the national stockpile against the objective, was signed by the President.

The U.S. Tariff Commission determined that imports of aluminum ingot from Canada, which had been the object of an investigation under the Antidumping Act of 1921 during part of 1972 and 1973, was neither injuring or nor likely to injure a domestic industry. As a result, aluminum ingot imported from Canada during that period was not subject to special dumping duties.

[1] Physical scientist, Division of Nonferrous Metals—Mineral Supply.

Table 1.—Salient aluminum statistics

(Thousand short tons and thousand dollars)

	1969	1970	1971	1972	1973
United States:					
Primary production	3,793	3,976	3,925	4,122	4,529
Value	2,013,403	2,190,087	2,154,446	r 2,084,946	2,206,440
Price: Ingot, average cents per pound	27.2	28.7	29.0	25.0	29.0
Secondary recovery	901	781	816	946	1,038
Exports (crude and semicrude)	575	612	293	329	561
Imports for consumption (crude and semicrude)	558	468	690	794	614
Consumption, apparent	4,710	4,519	5,099	5,588	5,685
World: Production	9,885	10,641	r 11,373	r 12,115	13,359

r Revised.

DOMESTIC PRODUCTION

Primary.—Production of primary aluminum increased 10% over that of 1972, despite a serious shortage of electric energy in the Pacific Northwest, which normally accounts for about one-third of total output. The power shortage was caused by low water conditions, and resulted in the closure of one or more potlines at some plants in the area for several months during the year. However, industry was able to obtain some alternate supplies of electric power albeit at higher costs. Water conditions improved at the end of the year and total production in the area was slightly higher in 1973 than that in the previous year.

Because of the stringent supply of petroleum products, which developed in the latter part of 1973 as a result of the oil producers embargo, domestic steel companies were considering burning coke oven tars, as a source of energy. Coke oven tar from the steel industry is the principal source of coal tar pitch used as a binder for carbon anodes used in the electrolytic reduction of alumina to aluminum metal. About 40 gallons of coal tar pitch is required per ton of primary aluminum produced and there was no known substitute for pitch binder for making aluminum anodes. Witco Chemical Co. announced plans to produce a suitable pitch binder from petroleum at a semicommercial plant at Perth Amboy, N. J. Silicon, a principal alloying element in aluminum also was in short supply during the year.

The Anaconda Aluminum Co. started production of primary aluminum from its new 120,000-ton-per-year plant at Sebree, Ky., and the Aluminum Company of America (Alcoa) increased its total primary aluminum capacity to 1,570,000 tons per year. Alcoa also began construction of a large new potline to expand its primary aluminum capacity at Massena, N.Y., to 190,000 tons per year by 1976, and began site preparation for construction of a 15,000-ton-per-year primary aluminum plant at Palestine, Tex. This new plant will use an experimental process involving electrolysis of aluminum chloride. The plant was expected to begin operations in 1975 and could eventually be expanded to 300,000 tons if the new technique, which requires 30% less electric energy than the present process, proves out.

American Metal Climax, Inc. (AMAX) and Howmet Corp. (Howmet), announced plans to expand annual production capacity of Howmet's Eastalco alumina reduction plant at Frederick, Md., by 86,700 short tons. A new company was expected to be formed to operate the Frederick facility, which would be owned 50% each by Howmet and AMAX. Mitsui & Co., Ltd., a primary aluminum producer in Japan also announced an agreement in principle to purchase half interest in AMAX's aluminum operations for $125 million.

Consolidated Aluminum Corp. (Conalco), 60% of which is owned by Swiss Aluminium Ltd. (Alusuisse) of Zurich, Switzerland, and the remainder by Phelps Dodge Corp., purchased the aluminum operations of Olin Corp. for $126 million. The Olin operations which were put up for sale in November 1972 included half interest in the primary aluminum plant at Hannibal, Ohio, plus a sheet and plate mill, two electrical conductor plants, and six other fabricating facilities.

Kaiser Industries Corp. and principal affiliates including Kaiser Aluminum & Chemical Corp., were discussing a broad technology exchange agreement with representatives of the U.S.S.R., which could result in the construction of primary aluminum plants utilizing the large hydroelectric power potential in Siberia.

Secondary.—Recovery of secondary aluminum, calculated from reports to the Bureau of Mines, was 1,038,480 short tons, 10.0% above the 1972 level. Calculated recovery of all metallic constituents from aluminum-base scrap increased 9.63% to 1,106,041 tons.

The Bureau estimated that full coverage of the industry would indicate a total scrap consumption of 1,472,000 short tons in 1973. Using this estimate, aluminum recovery totaled 1,147,000 short tons and metallic recovery was estimated at 1,235,000 tons.

Vulcan Materials Corp., a producer of secondary aluminum alloys, announced

Table 2.—Production and shipments of primary aluminum in the United States

(Short tons)

Quarter	1972 Production	1972 Shipments	1973 Production	1973 Shipments
First	975,842	1,000,381	1,111,655	1,155,124
Second	1,017,181	1,052,884	1,123,450	1,139,421
Third	1,044,857	1,032,915	1,127,223	1,130,202
Fourth	1,084,571	1,091,010	1,166,788	1,162,601
Total	4,122,451	4,177,190	4,529,116	4,587,348

Table 3.—Primary aluminum production capacity in the United States, by company

(Thousand short tons)

Company and plant	Capacity at yearend 1972	Capacity at yearend 1973	Ownership
Aluminum Company of America (Alcoa):			Self 100%.
Alcoa, Tenn	270		
Badin, N.C	115		
Evansville, (Warrick), Ind	275		
Massena, N.Y	130	1,570	
Point Comfort, Tex	185		
Rockdale, Tex	280		
Vancouver, Wash	115		
Wenatchee, Wash	175		
Total	1,545	1,570	
Anaconda Aluminum Co.:			Self 100%.
Columbia Falls, Mont	180	180	
Sebree, Ky	--	120	
Total	180	300	
Consolidated Aluminum Corp. (Conalco):			Swiss Aluminum Ltd. 60%; Phelps Dodge Corp. 40%.
Lake Charles, La	35	36	
New Johnsonville, Tenn	140	141	
Total	175	177	
Eastalco Aluminum Co.:			
Frederick, Md	87	88	Howmet Corp. 100%.
Martin Marietta Aluminum, Inc.:			Martin Marietta Corp. 87.2%.
The Dalles, Oreg	90	90	
Goldendale, Wash	110	111	
Total	200	201	
Intalco Aluminum Corp.:			American Metal Climax, Inc. 50%; Howmet Corp., 50%.
Ferndale (Bellingham), Wash	260	260	
Kaiser Aluminum & Chemical Corp.:			Self 100%.
Chalmette, La	260	260	
Mead, Wash	206	206	
Ravenswood, W. Va	163	163	
Tacoma, Wash	81	81	
Total	710	710	
National-Southwire Aluminum Co.:			National Steel Corp. 50%; Southwire Co., 50%.
Hawesville, Ky	180	180	
Noranda Aluminum Inc.:			Noranda Mines, Ltd., 100%.
New Madrid, Mo	70	70	
Ormet Corp.:			Conalco, 66%; Revere Copper & Brass, Inc. 34%.
Hannibal, Ohio	250	250	
Revere Copper & Brass, Inc.:			Self 100%.
Scottsboro, Ala	112	112	
Reynolds Metals Co.:			Self 100%.
Arkadelphia, Ark	63	68	
Corpus Christi (San Patricio), Tex	111	114	
Jones Mills, Ark	122	125	
Listerhill (Sheffield), Ala	221	202	
Longview, Wash	200	210	
Massena, N.Y	128	126	
Troutdale, Oreg	130	130	
Total	975	975	
Total United States	4,744	4,893	

plans to spend $6.5 million during the year to expand capacity. About $4.5 million of the total was expected to be used for pollution control equipment.

The Ohio Valley Aluminum Co. was expected to expand its secondary aluminum extrusion billet capacity at Shelbyville, Ohio, from 2,000 tons per month to 2,500 tons per month by the end of 1973. The Hall Aluminum Co. also was increasing capacity for producing secondary foundry-grade aluminum alloys and fluxes at its Chicago Heights, Ill., facility.

Apex Smelting Co., Inc., a subsidiary of AMAX, and a member of the AMAX Aluminum Group, announced plans to construct a new secondary aluminum and alloyed zinc production facility in Checotah, Okla. The $2.6 million facility, scheduled to go onstream in late 1974, will employ about 100 people and have an annual production capacity of up to 20,000 tons of secondary aluminum and 12,000 tons of alloyed zinc. The new facility will give Apex a total capacity of 92,000 tons of secondary aluminum when added to capacities of existing plants

Table 4.—Aluminum recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1972	1973 p
New scrap:		
Aluminum-base	[1] 755,762	[2] 841,966
Copper-base	99	132
Zinc-base	118	108
Magnesium-base	376	382
Total	756,355	842,588
Old scrap:		
Aluminum-base	[1] 188,594	[2] 196,514
Copper-base	51	68
Zinc-base	636	536
Magnesium-base	91	102
Total	189,372	197,220
Grand total	945,727	1,039,808

Form of recovery	1972	1973 p
As metal	79,535	121,020
Aluminum alloys	849,778	890,697
In brass and bronze	1,068	4,630
In zinc-base alloys	8,073	11,166
In magnesium alloys	2,042	3,526
In chemical compounds	5,231	8,769
Total	945,727	1,039,808

p Preliminary.

[1] Aluminum alloys recovered from aluminum-base scrap in 1972, including all constituents, were 795,649 tons from new scrap and 213,255 tons from old scrap and sweated pig, a total of 1,008,904 tons.

[2] Aluminum alloys recovered from aluminum-base scrap in 1973, including all constituents, were 886,461 tons from new scrap and 219,580 tons from old scrap and sweated pig, a total of 1,106,041 tons.

Table 5.—Consumption of and recovery from purchased new and old aluminum scrap in 1973 [1]

(Short tons)

Class	Consumption	Calculated recovery: Aluminum	Calculated recovery: Metallic
Secondary smelter	736,819	578,148	622,755
Primary producers	212,545	187,227	197,531
Fabricators	170,823	152,446	157,835
Foundries	133,483	113,793	120,736
Chemical producers	8,769	6,866	7,184
Total	1,262,439	1,038,480	1,106,041
Estimated full industry coverage	1,472,000	1,147,000	1,235,000

[1] Excludes recovery from other than aluminum-base scrap.

in Chicago, Ill., Cleveland, Ohio, and Long Beach, Calif.

Alcoa undertook a multimillion dollar expansion at its Warrick operations near Evansville, Ind., to enable it to recycle an additional 30,000 tons per year of aluminum beer and soft drink cans. The company's Warrick plant reportedly had a capacity to recycle about 110,000 tons of aluminum scrap per year, including container scrap.

American Can Co., formed a new company to market a recycling system for recovering aluminum, steel, and other materials from household wastes. The new firm, Americology, Inc., announced that the basic model of its system, costing about $2 to $3 million each, will process 500 tons of garbage per day (equivalent to the output of a typical city of 150,000 people). The firm also planned to provide continuing marketing and technical management counselling to purchasers of its system, and offered a guaranteed market for the ferrous scrap.

Table 6.—Stocks, receipts, and consumption of new and old aluminum scrap and sweated pig in the United States in 1973 [1]

(Short tons)

Class of consumer and type of scrap	Stocks Jan. 1 r	Receipts	Consumption	Stocks Dec. 31
Secondary smelters: [2]				
New scrap:				
Solids:				
Segregated low copper (Cu maximum, 0.4%)	5,065	151,086	150,814	5,337
Segregated high copper	525	10,434	9,617	1,342
Mixed low copper (Cu maximum, 0.4%)	2,594	96,774	97,158	2,210
High zinc (7000 series type)	468	6,399	6,690	177
Mixed clips	2,634	83,727	81,650	4,711
Borings and turnings:				
Low copper (Cu maximum, 0.4%)	786	28,467	28,418	835
Zinc, under 0.5%	334	11,455	11,226	563
Zinc, 0.5% to 1.0%	4,694	72,994	75,131	2,557
Foil, dross, skimmings	7,157	83,799	86,126	4,830
Other new scrap	1,335	22,291	22,368	1,258
Total new scrap	25,592	567,426	569,198	23,820
Old scrap (solids)	7,090	112,576	111,801	7,865
Sweated pig (purchased for own use)	4,014	55,494	55,820	3,688
Total all classes	36,696	735,496	736,819	35,373
Primary producers, foundries, fabricators, and chemical plants:				
New scrap:				
Solids:				
Segregated low copper (Cu maximum, 0.4%)	4,512	195,271	194,920	4,863
Segregated high copper	142	7,893	8,007	28
Mixed low copper (Cu maximum, 0.4%)	16,357	132,433	135,035	13,755
High zinc (7000 series type)	18	1,398	1,416	--
Mixed clips	113	5,152	4,979	286
Borings and turnings:				
Low copper (Cu maximum, 0.4%)	W	W	W	W
Zinc, under 0.5%	W	W	W	W
Zinc, 0.5% to 1.0%	W	W	W	W
Foil, dross, skimmings	739	5,947	6,279	407
Other new scrap	1,436	79,024	79,918	542
Total new scrap [3]	23,444	427,667	431,164	19,947
Old scrap (solids)	4,407	61,454	64,601	1,260
Sweated pig (purchased for own use)	4,838	28,497	29,855	3,480
Total all classes	32,689	517,618	525,620	24,687
Total of all scrap consumed:				
New scrap:				
Solids:				
Segregated low copper (Cu maximum, 0.4%)	9,577	346,357	345,734	10,200
Segregated high copper	667	18,327	17,624	1,370
Mixed low copper (Cu maximum, 0.4%)	18,951	229,207	232,193	15,965
High zinc (7000 series type)	486	7,797	8,106	177
Mixed clips	2,747	88,879	86,629	4,997
Borings and turnings:				
Low copper (Cu maximum, 0.4%)	786	28,478	28,429	835
Zinc, under 0.5%	334	11,496	11,267	563
Zinc, 0.5% to 1.0%	4,821	73,491	75,689	2,623
Foil, dross, skimmings	7,896	89,746	92,405	5,237
Other new scrap	2,771	101,315	102,286	1,800
Total new scrap [3]	49,036	995,093	1,000,362	43,767
Old scrap (solids)	11,497	174,030	176,402	9,125
Sweated pig (purchased for own use)	8,852	83,991	85,675	7,168
Total all classes	69,385	1,253,114	1,262,439	60,060

r Revised. W Withheld to avoid disclosing individual company confidential data.
1 Includes imported scrap.
2 Excludes secondary smelters owned by primary aluminum companies.
3 Includes data withheld.

Table 7.—Production and shipments of secondary aluminum alloys by independent smelters

(Short tons) [1]

	1972 [2]		1973 [2]	
	Production	Shipments	Production	Shipments
Pure aluminum (Al minimum, 97.0%)	79,535	77,455	121,020	123,097
Aluminum-silicon:				
95/5 Al-Si, 356, etc. (Cu maximum 0.6%)	18,769	18,907	19,579	19,977
13% Si, 360, etc. (Cu maximum 0.6%)	56,738	57,184	56,899	58,182
Aluminum-silicon (Cu 0.6% to 2%)	3,874	4,106	3,981	4,029
No. 12 and variations	9,029	8,658	10,407	11,037
Aluminum-copper (Si maximum 1.5%)	1,068	952	4,630	4,577
No. 319 and variations	50,681	50,815	62,347	62,739
Nos. 122 and 138	18	43	53	49
380 and variations	380,103	382,781	405,585	410,442
Aluminum-silicon-copper-nickel	8,576	9,824	4,672	4,985
Deoxidizing and other destructive uses:				
Grades 1 and 2	15,811	15,841	23,580	24,006
Grades 3 and 4	6,062	6,322	6,491	5,924
Aluminum-base hardeners	5,732	5,704	7,351	7,487
Aluminum-magnesium	2,042	1,985	3,526	3,476
Aluminum-zinc	8,073	8,059	11,166	11,530
Miscellaneous	33,953	34,256	20,809	20,661
Total	680,064	682,892	762,096	772,198

[1] Gross weight, including copper, silicon, and other alloying elements. Secondary smelters used 16,300 and 34,797 tons of primary aluminum in 1972 and 1973, respectively, in producing secondary aluminum-based alloys.
[2] No allowance was made for consumption or receipts by producing plants.

CONSUMPTION

Aluminum demand continued strong in 1973, and consumption, as measured by shipments of aluminum ingot and mill products to domestic users, surged upward by 18.6%. Total shipments including exports increased by 20.8%.

The transportation market, representing the second largest market for aluminum products, gained about 26% over that of the previous year, and had the largest quantity increase of any of the major markets. The estimated average use of aluminum in 1974 model cars was about 80 pounds per unit compared with about 78 pounds in 1973 models. The increase was attributed to greater use of aluminum in the General Motors Corp. Vega engine, in bumpers, air conditioning, and some body sheet, especially for hoods.

Table 8.—Distribution of end-use shipments of aluminum products

Industry	1972 r		1973	
	Quantity (thousand short tons)	Percent of total	Quantity (thousand short tons)	Percent of total
Building and construction	1,597	26.5	1,799	25.0
Transportation	1,112	18.5	1,405	19.3
Containers and packaging	906	15.0	1,029	14.1
Electrical	768	12.8	927	13.0
Consumer durables	564	9.3	669	9.1
Machinery and equipment	375	6.2	475	6.5
Other markets	414	6.9	435	6.0
Statistical adjustment	6,023	100.0	7.228	100.0
Total to domestic users	[1] 5,742	95.3	[1] 6,808	94.0
Exports	281	4.7	420	6.0
Total	6,023	100.0	7,228	100.0

r Revised.
[1] Data may not add to totals shown because of independent rounding.
Source: The Aluminum Association.

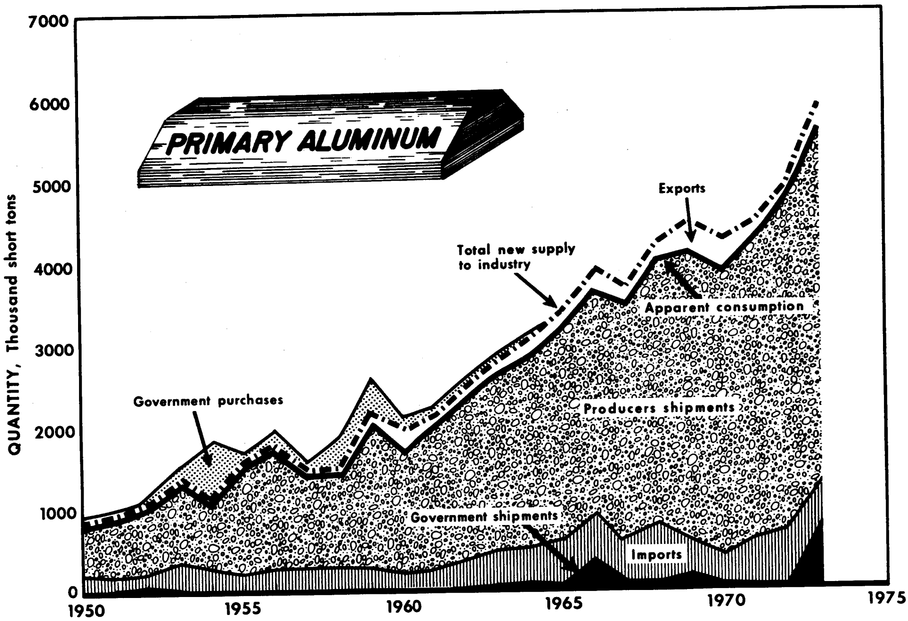

Figure 1.—Components of domestic supply and distribution of primary aluminum.

Table 9.—Apparent consumption of aluminum in the United States

(Short tons)

Year	Primary sold or used by producers	Imports (net) [1]	Recovery from old scrap [2]	Recovery from new scrap [2]	Total apparent consumption
1969	3,821,001	−11,419	148,205	752,625	4,710,412
1970	3,878,920	−141,796	145,576	635,843	4,518,543
1971	3,887,429	+396,408	167,030	648,138	5,099,005
1972	4,177,190	+466,765	188,594	755,762	5,588,311
1973	4,587,348	+59,484	196,514	841,966	5,685,312

[1] Crude and semicrude. Includes ingot equivalent of scrap imports and exports (weight multiplied by 0.9).
[2] Aluminum content.

An Alcoa study, described in a report,[2] showed that about 52 pounds of aluminum (about 75% of which was in engine parts such as pistons, carburetors, fuel pumps, etc.) was used in light trucks weighing about 6,000 to 10,000 pounds per unit. Remaining uses of aluminum in light trucks included body, hardware and trim applications (about 18% of the total), and air conditioners (5%). Alcoa estimated that the average large truck tractor with a gross weight (including the trailer) of over 33,000 pounds used 785 pounds of aluminum mainly in the cab, frame, radiator, fuel tanks, wheels, battery boxes, bumpers, and air conditioners. The average use of aluminum in all trucks increased 3½ pounds per unit to an estimated 99 pounds per unit in 1974 models.

Shipments for machinery and equipment applications, which include special industrial machinery, chemical processing and material handling equipment, irrigation pipe, and service equipment and supplies, had the largest percentage gain, reaching 475,000 tons, 26.7% above that of the previous year.

Shipments to the electrical industry also increased sharply to 1,029,000 tons, 21%

[2] Rakowski, Leo R. Trucks Go Light With Aluminum. Mod. Metals, v. 29, No. 5, June 1973, pp. 49–62.

higher than in 1972. Part of this increase was attributed to the expansion of the use of copper-clad aluminum conductors, which can be satisfactorily joined with a good electrical connection. Shipments of copper-clad aluminum conductors for wiring houses reportedly exceeded shipments of solid aluminum conductors for that purpose and continued to gain on solid copper conductors for houses.[3]

Consumption of aluminum for air conditioners, cooking utensils, refrigerators, and other consumer durables increased about 19% to 669,000 tons. The increases in aluminum shipments for building and construction and the container and packaging markets of 13% and 14%, respectively, were below the overall average increase for consuming industries.

The use of aluminum coatings to improve the corrosion resistance of steel roofing and structural components was expected to triple by 1976.[4] About 0.8 ounce of aluminum per square foot of steel surface was said to reflect up to 80% of the radiant heat that strikes it and does not need any initial or maintenance painting. The aluminized steel could be fabricated into a variety of shapes, only one coating of porcelain enamel was required on the outside of aluminized steel compared with a double coating of porcelain required on the outside of untreated steel, and was available in strengths up to 50,000 pounds per square inch. A porcelain coating was not required on interior surfaces protected with aluminum.

[3] Polleys, William. Copper-Clad Aluminum: A Wire Success Story. Am. Metal Market, v. 80, No. 206, Oct. 24, 1973, pp. 2A-3A.
[4] Light Metal Age. Aluminized Steel, Booming Growth Seen In The Construction Industry. V. 31, No. 7/8, August 1973, pp. 19-20.

Table 10.—Net shipments of aluminum wrought [1] and cast products by producers

(Short tons)

	1972	1973 p
Wrought products:		
Sheet, plate, and foil	2,993,850	3,257,856
Rolled and continuous cast rod and bar, wire	690,144	675,221
Extruded rod, bar, pipe, tube, shapes; drawn and welded tubing and rolled structural shapes	1,188,081	1,317,781
Powder, flake, and paste	113,185	128,698
Forgings (including impacts)	61,383	71,186
Total	5,046,643	5,450,742
Castings:		
Sand	114,820	129,825
Permanent mold	209,888	220,100
Die	596,086	652,184
Others	7,042	10,918
Total	927,836	[2] 1,013,027
Grand total	5,974,479	6,463,769

p Preliminary.
[1] Net shipments derived by subtracting the sum of producers' domestic receipts of each mill shape from the domestic industry's gross shipment of that shape.
[2] Subject to possible upward revision of approximately 10% to 15%.

Table 11.—Distribution of wrought products

(Percent)

	1972	1973 p
Sheet, plate, and foil:		
Non-heat-treatable	50.1	49.7
Heat-treatable	2.6	2.9
Foil	6.7	7.1
Rolled and continuous cast rod and bar; wire:		
Rod, bar, etc	4.3	2.7
Bare, wire conductor and nonconductor	1.1	1.1
Bare cable (including steel-reinforced)	4.6	4.5
Wire and cable, insulated or covered	3.7	4.1
Extruded products:		
Rod and bar	.8	.6
Pipe and tubing	1.9	2.1
Shapes [1]	18.7	19.4
Tubing:		
Drawn	.9	1.0
Welded, non-heat-treatable [2]	1.2	1.1
Powder, flake, and paste:		
Atomized	1.8	1.9
Flaked	(3)	(3)
Paste	.2	.3
Powder, n.e.c	.2	.2
Forgings (including impacts)	1.2	1.3
Total	100.0	100.0

p Preliminary.
[1] Includes a small amount of rolled structural shapes.
[2] Includes a small amount of heat-treatable welded tube.
[3] Less than 0.1%.

STOCKS

Reflecting the strong upturn in demand, industry stocks of primary aluminum ingot at reduction plants declined from 120,465 tons (revised) at the beginning of the year to 62,234 tons at yearend. Although all producers do not report stocks of aluminum at reduction plants to the Bureau of Mines, the Bureau of Domestic Commerce (BDC) reported that the total metal inventory held by the aluminum industry, which includes stocks of all metal forms at reduction and other processing plants, also declined. Total industry stocks of aluminum metal, including scrap, dropped from 2,430,584 tons (revised) at the beginning of the year to 2,183,031 tons at yearend.

PRICES

The major domestic producers price for primary aluminum, quoted in the American Metal Market at the beginning of 1973, was 25 cents per pound, and was raised to 29 cents per pound at yearend. By the end of estimated the market price for primary aluminum at about 20 cents per pound in January, 23 to 23.5 cents per pound in March, 25 cents per pound in May, and 33 cents per pound at yearend. By the end of the year the estimated world market price for primary aluminum was 36 to 38 cents per pound, compared to an estimated 28 to 30 cents per pound at the beginning of the year.

In the middle of the year requests by two leading domestic aluminum companies to increase the aluminum base or ceiling price for primary aluminum to 29 cents per pound, which prevailed in May 1970 when market prices were believed to be about 26 to 27 cents per pound, was rejected by the Cost of Living Council (CLC). Anaconda and Alcan were permitted under price regulations to raise their price for primary aluminum to 27.5 cents per pound in October. On December 6, the CLC restored the May 1970 base price for aluminum of 29 cents per pound and, after subsequent clarifications by the CLC, all major domestic producers raised their quoted prices to that level by the end of the year.

Prices (in cents per pound) quoted by the American Metal Market for aluminum-base scrap and secondary alloy ingot, also increased markedly during the year, as follows:

	Jan. 2, 1973	Dec. 31, 1973
Aluminum clippings (new scrap)	11.5 –15.5	19.00–24.00
Old cast scrap	11.5 –12.25	17.00–18.00
Smelter's alloys (secondary alloy ingot, excluding deoxidizing ingot)	26.75–32.00	34.00–40.00

Increased costs for silicon, a major alloying ingredient in secondary aluminum alloy ingot was credited with causing part of the increase in the price of secondary aluminum alloys, as well as the increase in aluminum-base scrap prices.

FOREIGN TRADE

Despite strong domestic demand, exports of crude and semicrude aluminum metal, including scrap, were 70% higher than those in 1972. Most of the increase was in the form of aluminum ingot, slabs and crude, the total quantity of which was more than double that in 1972. Aluminum scrap exports also were more than double those of 1972. Canada was the principal destination of U.S. aluminum exports, receiving 24% of the crude and semicrude aluminum shipped, chiefly in the form of ingot and scrap. Of the ingot, slabs, and other crude forms exported, Japan, Canada, Argentina, West Germany and Mexico, in that order, were the principal recipients.

U.S. imports for consumption of crude and semicrude aluminum decreased to 613,606 short tons, 29% less than 1972 imports. Aluminum in the form of metal and alloys, ingots, and other crude forms, as in past years dominated imports, accounting for 83% of the total. Scrap imports declined 12% during the year to 46,808 tons. As in past years, Canada was the principal source of U.S. aluminum imports, accounting for 85% of the ingot and other crude forms and for 85% of the scrap imports. Other principal sources of imported ingot and other crude forms were Ghana, Norway, Surinam, and the United Kingdom.

Table 12.—U.S. exports of aluminum, by class

Class	1972		1973	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Crude and semicrude:				
Ingots, slabs, crude	108,319	$51,879	229,578	$121,951
Scrap	66,039	21,072	115,120	39,936
Plates, sheets, bars, etc	144,987	115,279	202,371	178,482
Castings and forgings	4,467	11,681	5,277	14,613
Semifabricated forms, n.e.c	5,282	9,329	8,637	15,388
Total	329,094	209,240	560,983	370,370
Manufactures:				
Foil and leaf	7,459	11,828	11,090	17,406
Powders and pastes	2,757	2,110	5,954	4,503
Wire and cable	10,229	9,050	9,194	9,457
Total	20,445	22,988	26,238	31,366
Grand total	349,539	232,228	587,221	401,736

Table 13.—U.S. exports of aluminum, by class and country

Country	1972						1973					
	Ingots, slabs, crude		Plates, sheets, bars, etc.[1]		Scrap		Ingots, slabs, crude		Plates, sheets, bars, etc.[1]		Scrap	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Argentina	16,222	$6,405	1,799	$873	1	(2)	23,441	$11,639	379	$637	1	(3)
Australia	49	35	1,053	1,251	3	$1	1,513	917	2,042	2,492	55	$27
Belgium-Luxembourg	11,427	4,956	269	454	522	164	4,995	2,048	547	823	346	123
Brazil	2,506	1,089	1,632	1,705	1,187	323	6,585	3,404	2,384	2,347	5,293	2,013
Canada	19,058	10;186	91,589	72,876	4,312	1,528	34,141	18,471	91,822	83,674	9,193	2,977
Chile	407	224	10	19	12	4	240	127	13	20	20	10
Colombia	4	5	281	301	5	2	1,137	597	667	492	2	2
Denmark	47	77	2,404	2,048	--	--	4	1	5,014	4,287	--	--
El Salvador	1,429	692	549	329	--	--	1,414	688	760	462	--	--
France	1,647	938	821	1,099	386	155	1,869	1,041	1,705	1,946	1,456	447
Germany, West	8,887	4,344	5,264	7,533	12,873	3,659	21,484	11,980	9,909	15,593	14,337	4,925
Ghana	301	223	105	95	--	--	22	35	1,274	903	--	--
Guinea	--	--	1,084	966	--	--	--	--	1,305	1,108	--	--
Hong Kong	1,742	877	474	475	--	--	1,291	638	670	735	9	3
Iran	3,272	1,489	214	196	5	2	34	17	778	792	--	--
Israel	22	13	720	979	--	--	101	83	1,233	1,602	--	--
Italy	888	576	2,783	4,083	1,854	494	6,892	3,926	4,708	7,134	6,096	2,135
Jamaica	13	15	223	270	17	4	9	6	883	858	--	--
Japan	13,956	6,583	4,466	5,151	31,405	10,256	48,239	26,452	16,010	14,913	45,184	19,084
Korea, Republic of	519	240	161	201	6,794	2,392	1,490	751	276	423	10,307	2,888
Mexico	524	286	10,162	6,607	287	32	12,652	7,150	22,996	14,304	164	45
Netherlands	1,575	966	3,043	3,156	294	91	5,487	2,702	7,321	7,722	252	100
New Zealand	879	473	307	310	--	--	16	20	1,021	1,162	--	--
Norway	48	67	387	403	--	--	126	192	2,158	2,895	--	--
Pakistan	665	330	581	363	742	209	3,914	1,852	1,709	1,078	1,094	331
Panama	545	257	69	104	2	1	968	435	280	427	--	--
Peru	93	49	98	166	799	403	218	107	24	55	692	351
Philippines	5,013	2,512	153	217	66	37	8,921	4,742	298	449	139	78
South Africa, Republic of	1	2	2,284	2,074	--	--	36	21	4,418	4,196	--	--
Spain	3	1	511	422	1,627	321	764	446	605	621	1,826	369
Sweden	7	5	924	1,057	--	--	453	194	531	729	35	15
Switzerland	1,917	943	862	900	--	--	2,135	1,033	380	374	--	--
Taiwan	6,146	2,549	200	319	991	420	10,208	4,684	267	350	15,409	2,736
Thailand	4,818	2,221	25	43	--	--	8,611	4,693	159	170	365	247
United Kingdom	1,241	722	13,703	13,007	1,266	368	3,733	1,847	22,032	21,350	2,606	935
Venezuela	97	102	1,583	1,599	1	1	2,147	1,123	4,239	4,056	1	1
Other	2,351	1,427	3,943	4,638	588	205	14,288	7,889	5,468	7,304	238	94
Total	108,319	51,879	154,736	136,289	66,039	21,072	229,578	121,951	216,285	208,483	115,120	39,936

[1] Includes plates, sheets, bars, extrusions, forgings, and unclassified semifabricated forms.
[2] Less than ½ unit.

Table 14.—U.S. imports for consumption of aluminum, by class

Class	1972 Quantity (short tons)	1972 Value (thousands)	1973 Quantity (short tons)	1973 Value (thousands)
Crude and semicrude:				
Metals and alloys, crude	661,042	$304,536	508,025	$225,256
Circles and disks	9,907	6,597	7,752	5,663
Plates, sheets, etc., n.e.c	59,616	36,941	42,262	29,982
Rods and bars	9,428	6,671	7,293	5,731
Pipes, tubes, etc	2,191	2,242	1,466	1,846
Scrap	52,301	17,747	46,808	16,740
Total	794,485	374,734	613,606	285,218
Manufactures:				
Foil	12,266	14,851	9,184	14,610
Leaf (5.5 by 5.5 inches)	(1)	84	(1)	82
Flakes and powders	225	298	219	416
Wire	743	542	602	730
Total	13,234	15,775	10,005	15,838
Grand total	807,719	390,509	623,611	301,056

[1] 1972: 7,959,116 leaves and 167,764,497 square inches; 1973: 2,269,800 leaves, and 132,057,391 square inches.

Table 15.—U.S. imports for consumption of aluminum, by class and country

Country	1972 Metals and alloys, crude Quantity (short tons)	1972 Metals and alloys, crude Value (thousands)	1972 Plates, sheets, bars, etc.[1] Quantity (short tons)	1972 Plates, sheets, bars, etc.[1] Value (thousands)	1972 Scrap Quantity (short tons)	1972 Scrap Value (thousands)	1973 Metals and alloys, crude Quantity (short tons)	1973 Metals and alloys, crude Value (thousands)	1973 Plates, sheets, bars, etc.[1] Quantity (short tons)	1973 Plates, sheets, bars, etc.[1] Value (thousands)	1973 Scrap Quantity (short tons)	1973 Scrap Value (thousands)
Australia	--	--	3	$3	--	--	--	--	24	$15	--	--
Belgium-Luxembourg	5	$3	2,376	1,699	--	--	--	--	2,119	1,799	--	--
Austria	--	--	35,299	20,551	31	$8	--	--	21,726	14,266	--	--
Canada	508,231	230,211	5,522	4,777	44,452	15,399	430,116	$189,058	5,129	4,504	39,804	$14,022
France	17,220	8,408	14,225	9,374	--	--	1,003	481	9,705	6,806	--	--
Germany, West	8	8	1,033	1,047	1,843	515	103	57	1,408	1,674	630	287
Ghana	40,613	19,467	--	--	133	68	40,561	19,513	--	--	321	132
Italy	220	57	3,975	2,734	(2)	(2)	--	--	2,433	1,781	--	--
Japan	170	131	8,950	5,902	--	--	166	124	6,331	4,902	55	20
Mexico	4,967	2,829	17	24	775	124	1,560	660	4	6	1,114	214
Norway	63,909	31,077	293	157	25	9	13,416	6,477	622	399	546	232
Poland	551	193	--	--	--	--	29	59	--	--	--	--
Spain	--	--	1,013	648	--	--	2	4	1,174	823	--	--
Surinam	--	--	--	--	--	--	12,258	4,754	--	--	--	--
Sweden	--	--	100	95	225	85	59	24	33	56	744	699
Switzerland	--	--	226	192	--	--	10	8	54	60	--	--
United Kingdom	24,516	11,819	184	208	4,040	1,275	8,653	3,965	294	327	660	267
Yugoslavia	6	3	6,330	4,110	--	--	--	--	5,455	4,150	--	--
Other	r 626	r 330	1,596	930	777	264	89	72	2,262	1,654	2,934	867
Total	661,042	304,536	81,142	52,451	52,301	17,747	508,025	225,256	58,773	43,222	46,808	16,740

r Revised.
[1] Includes circles, disks, bars, rod, plates, sheets, pipes, etc.
[2] Less than ½ unit.

WORLD REVIEW

Estimated world demand for primary aluminum surged ahead by about 12% over that of the previous year. Shortages of electric energy supplies held output growth significantly below the potential in the United States and Japan and caused a decline in production in India. As a result, world production of primary aluminum was up only 10%. Although sales from government-held stocks in the United States helped avert a drastic shortage in that country, supply was tight in all major consuming areas during most of the year. Some 10% to 15% of the electric energy used to produce primary aluminum in many countries is believed to be based on oil-fired thermal generating plants. The sharp increase in world oil prices during the latter part of 1973 compounded energy supply problems and accelerated industry interest in locating aluminum plants near sources of low-cost thermal or hydroelectric power, most of which are found outside major consuming areas.

Large expansions of primary aluminum capacity, however, were completed in 1973 in major consuming countries, including Italy, Japan, Spain, the United Kingdom, and the United States. Countries which were being considered for aluminum plants because of energy availability included Abu Dhabi, Brazil, Indonesia, Kuwait, Qatar Shiekdom, Saudi Arabia, and Venezuela.

Argentina.—Aluminio Argentino S.A. (ALUAR), apparently continued construction of the 140,000-ton-per-year primary aluminum plant at Puerto Madryn in Chubut Province, but it appeared unlikely that the plant would begin significant production before 1975 because of delays in completing the hydroelectric power facilities on the Futaleufu River. Beginning in late 1974 or early 1975, 100,000 tons of alumina from Australia was scheduled to be delivered annually to the plant under a contract with Alcoa.

Australia.—The Tasmanian State Government reportedly was considering construction of a 170,000-ton-per-year primary aluminum plant in cooperation with Nippon Light Metals Co. Ltd. (NLM) and other Japanese interests. By 1977, Comalco Industries Pty. Ltd. reportedly planned to construct an 88,000-ton-per-year primary aluminum plant near Gladstone, Queensland.

Brazil.—Companhia Mineira de Alumínio, S.A., 50% owned by Alcoa, was expected to increase capacity at its alumina reduction facilities at Poços de Caldas to about 70,000 tons per year by 1976. The capacity of the Companhia Brasileira de Alumínio S.A. (CBA) primary plant at Sorocaba was to be raised to 77,000 tons per year by 1976. Capacity at the Alumínio Minas Gerais, S.A. plant at Arutü, owned by Alcan, was raised to 15,000 tons per year. Capacity at Alcan's Saramenha facility was

Table 16.—Aluminum: World production by country [1]

(Thousand short tons)

Country	1971	1972	1973 p
North America:			
Canada	1,121	1,013	1,030
Mexico	44	44	43
United States	3,925	4,122	4,529
South America:			
Brazil	98	107	125
Surinam	60	58	57
Venezuela	25	26	26
Europe:			
Austria	100	93	98
Czechoslovakia	41	42	46
France	423	434	397
Germany, East e	65	65	101
Germany, West	471	490	587
Greece	128	143	157
Hungary [2]	74	75	74
Iceland	45	50	79
Italy	132	134	203
Netherlands	128	183	209
Norway	584	604	684
Poland [2]	110	112	112
Romania [3]	123	134	155
Spain	139	154	185
Sweden	r 82	85	91
Switzerland	104	92	94
U.S.S.R. e	1,300	1,380	1,500
United Kingdom	131	189	277
Yugoslavia	51	80	100
Africa:			
Cameroon	56	51	49
Ghana	122	159	168
South Africa, Republic of	32	58	58
Asia:			
Bahrian	11	86	114
China, People's Republic of e	150	150	160
India	r 194	197	170
Iran	--	11	48
Japan [4]	r 984	1,118	1,215
Korea, Republic of	19	17	20
Taiwan	29	35	39
Turkey	--	--	e 10
Oceania:			
Australia	r 247	227	e 228
New Zealand	r 25	97	e 121
Total	r 11,373	12,115	13,359

e Estimate. p Preliminary. r Revised.

[1] Output of primary unalloyed ingot unless otherwise specified.

[2] Includes secondary.

[3] Includes alloys.

[4] Includes super-purity aluminum as follows in short tons: 1971—6,706; 1972—6,313; 1973—6,526.

Table 17.—World producers of primary aluminum

(Thousand short tons)

Country, company, plant location	Capacity, yearend 1973	Ownership
NORTH AMERICA		
Canada:		
Aluminium Company of Canada, Ltd.:		Alcan Aluminium Ltd. 100%.
Arvida, Quebec	458	
Beauharnois, Quebec	52	
Isle Maligne, Quebec	130	
Kitimat, British Columbia	300	
Shawinigan Falls, Quebec	95	
Total	1,035	
Canadian Reynolds Metals Co. Ltd.:		Reynolds Metals Co. 100%.
Baie Comeau, Quebec	175	
Total Canada	1,210	
Mexico:		
Alumínio, S.A. de C.V., Vera Cruz	44	Aluminum Co. of America 44%; private Mexican interests 56%.
United States: (see table 3)	4,893	
Total North America	6,147	
SOUTH AMERICA		
Brazil:		
Alumínio Minas Gerais, S.A.:		Alcan Aluminium Ltd. 100%.
Saramenha (Ouro Prêto)	35	
Arutü, Bahia	15	
Companhia Brasileira de Alumínio S.A. (C.B.A.):		Industria Votorantim, Ltd. 80%; Government 20%.
Sorocaba, São Paulo	44	
Companhia Mineira de Alumínio, S.A.:		Aluminum Co. of America 50%; Hanna Mining Co. 23.5%; Minas Gerais State 26.5%.
Poços de Caldas, Minas Gerais	28	
Total Brazil	122	
Surinam:		
Suriname Aluminium Co. (Suralco):		Aluminum Co. of America 100%.
Paranam	73	
Venezuela:		
Alumínio del Caroni, S.A. (Alcasa) Matanzas	25	Reynolds Metals Co. 50%; Government 50%.
Total South America	220	
EUROPE		
Austria:		
Salzburger Aluminum GmbH (SAG):		Alusuisse 100%.
Lend, Salzburg	13	
Vereinigte Metallwerke Ranshofen-Berndorf, A.G. (VMRB):		Government 100%.
Ranshofen, Braunau-am-Inn	88	
Total Austria	101	
Czechoslovakia:		
Ziar Aluminium Works:		Government 100%.
Ziar-on-Hron	72	
France:		
Péchiney Ugine Kuhlmann Group (PUK):		Self 100%.
Auzat, Ariége	33	
Chedde, Haute-Savoie	9	
La Praz, Savoie	4	
L'Argentiére, Haute-Alpes	42	
La Saussaz, Savoie	13	
Nogueres, Basses-Pyrénées	127	
Rioupéroux-Isére	26	
St. Jean de Maurienne-Savoie	91	
Sabart-Ariége	26	
Lannemezan-Haute Pyrénées	58	
Venthon-Savoie	28	
Total France	457	
Germany, East:		
Electrochemisches Kombinat:		Government 100%.
Bitterfeld	55	
Lautawerk	33	
Total Germany, East	88	

Table 17.—World producers of primary aluminum—Continued

(Thousand short tons)

Country, company, plant location	Capacity, yearend 1973	Ownership
EUROPE—Continued		
Germany, West:		
Aluminium-Hütte Rheinfelden GmbH:		Alusuisse 99.85%.
Rheinfelden, Baden	61	
Vereinigte Aluminium-Werke A.G. (VAW):		Government 100%.
Erftwerke, Grevenbroich	40	
Innwerke, Toging	77	
Lippenwerke, Lunen	55	
Norf, Rheinwerke	154	
Elbewerk, Stade	88	
Gebrueder Giulini GmbH:		Gebrueder Giulini GmbH 100%.
Ludwigshafen	22	
Kaiser-Preussag Aluminium GmbH:		Kaiser 50%; Preussag A.G. 50%.
Voerde	71	
Leichtmetall GmbH, Essen	139	Metallgesellschaft A.G. 50%; Alusuisse 50%.
Reynolds Aluminium Hamburg GmbH:		Reynolds International, Inc. 90%; City of Hamburg 10%.
Hamburg	110	
Total Germany, West	817	
Greece:		
Aluminium de Grèce S.A. (ADG) Distomon	160	Péchiney 72%; Ugine 18%; Government 10%.
Hungary:		
Magyarsoviet Bauxite Ipar:		Government 100%.
Ajka	19	
Inota	33	
Tatabanya	17	
Total Hungary	69	
Iceland:		
Icelandic Aluminium Co., Hafnarfjordur	83	Alusuisse 100%.
Italy:		
Alcan Alluminio Italiano S.p.A.:		Alcan Aluminium Ltd. 100%.
Borgo-Franco d'Ivrea	4	
Alumetal S.p.A.:		Government 94%; Montecatini Edison 6%.
Bolzano	66	
Fusina	40	
Mori	26	
Societá Alluminio Veneto per Azioni S.p.A. (SAVA):		Alusuisse 50%; Government 50%.
Fusina	33	
Porto Marghera	33	
Aluminio Sardo S.p.A. (ALSAR):		Government 94%; Montecatini Edison 6%.
Porto Vesme, Sardinia	110	
Total Italy	312	
Netherlands:		
Aluminium Delfzijl N.V. (Aldel), Delfzijl	106	Holland Aluminium N.V. 100%.
Péchiney Nederland N.V., Vlissingen (Flushing)	94	Péchiney 85%; Hunter-Douglas 15%.
Total Netherlands	200	
Norway:		
Norsk Hydro A/S Karmøy Fabrikker (Alnor):		Norsk Hydro 100%. (Government 50%)
Karmøy Island	115	
A/S Årdal og Sunndal Verk (ASV):		Government 50%; Alcan 50%.
Årdal	194	
Høyanger	33	
Sunndalsora	132	
Det Norske Nitridaktieselskap (DNN):		Alcan 50%; British Aluminium 50%.
Eydehavn	16	
Tysseldal	27	
Mosjøen Aluminiumverk A/S (Mosal), Mosjoen	105	Alcoa 50%; Elkem 50%.
Søer-Norge Aluminium A/S (Soral), Husnes	77	Alusuisse 67%; Compadec and other interests 33%.
Lista Aluminiumverk A/S (Elkem), Lista	62	Alcoa 50%; Elkem 50%.
Total Norway	761	
Poland: Ministry of Heavy Industry:		Government 100%.
Konin Works	61	
Skawina Works	61	
Total Poland	122	

Table 17.—World producers of primary aluminum—Continued

(Thousand short tons)

Country, company, plant location	Capacity, yearend 1973	Ownership
EUROPE—Continued		
Romania:		
Slatina	120	Government 100%.
Spain:		
Alumínio de Galicia, S.A.:		Péchiney 66%; Endasa 17%; Government 17%.
La Coruña	61	
Sabinanego, Huesca	15	
Empresa Nacional del Alumínio, S.A. (ENDASA):		Government 50.5%; Alcan 25%; Banco-deBilbao 15%; Spanish interests 9.5%.
Aviles	88	
Valladolid	26	
Total Spain	190	
Sweden:		
A/B Svenska Aluminiumkompaniet (Sako) Sundsvall, Kubikenborg	95	Svenska Metallverken 79%; Alcan 21%.
Switzerland:		
Swiss Aluminium Ltd. (Alusuisse):		Alusuisse 100%.
Chippis	35	
Steg	53	
Usine d'Aluminium Martigny, S.A. Martigny	12	Self 100%.
Total Switzerland	100	
U.S.S.R.:		Government 100%.
Bogoslovsk (Krasnoturinsk) Sverdlovskaya Oblast, Urals	154	
Bratsk, Irkutskaya Oblast, Siberia	220	
Irkutsk (Shelekovo) Irkutskaya Oblast, Siberia	220	
Kamensk-Ural'skiy, Sverdlovskaya Oblast, Urals	154	
Kanaker (Yerevan), Armenia	83	
Kandalaksha, Murmanskaya Oblast	33	
Krasnoyarsk, Krasnoyarskiy Kray, Siberia	220	
Nadvoitsy, Karelskaya, A.S.S.R	39	
Novokuznetsk (Stalinsk) Kemeroyskaya Oblast, Siberia	138	
Sumgait (Kirovabad), Azerbaijan	83	
Volgograd (Stalingrad) Volgogradskaya Oblast	135	
Volkhov (Zvanka), Leningrad Oblast	22	
Zaporozhye (Dneprovsk) Zaporozhskaya Oblast, Ukraine	77	
Total U.S.S.R	1,578	
United Kingdom:		
The British Aluminium Co., Ltd. (BA):		Tube Investments, Ltd. 49%; Reynolds Metals Co. 48%.
Kinlochleven, Scotland	11	
Lochaber (Ft. William), Scotland	32	
Invergordon, Scotland	112	
Alcan (UK) Ltd.:		Alcan 100%.
Lynemouth, Northumberland	132	
Anglesey Aluminium Ltd.:		Rio Tinto-Zinc Corp., Ltd. 47%; Kaiser Aluminum & Chemical Corp. 34%; British Insulated Callenders Cables, Ltd. 19%.
Holyhead, New Wales, Scotland	112	
Total United Kingdom	399	
Yugoslavia:		Government 100%.
Kidricevo, Slovenia	55	
Lozovac, Croatia	7	
Titograd, Montenegro	55	
Sibenik (Boris Kidric), Croatia	83	
Total Yugoslavia	200	
Total Europe	5,924	
AFRICA		
Cameroon: Compagnie Camerounaise de l'Aluminium Péchiney Ugine (Alucam), Edea	61	Péchiney 48%; Ugine 12%, Cobeal 10%, Comal Cie 30%.
Ghana: Volta Aluminium Corp. (Valco): Tema	162	Kaiser 90%; Reynolds 10%.

Table 17.—World producers of primary aluminum—Continued

(Thousand short tons)

Country, company, plant location	Capacity, yearend 1973	Ownership
AFRICA—Continued		
South Africa, Republic of:		
Alusaf (Pty.) Ltd., Richards Bay	57	Industrial Development Corp. (Government) and private South African interests 78%; Alusuisse 22%.
Total Africa	280	
ASIA		
Bahrain: Aluminium Bahrain (ALBA)	132	Kaiser Aluminium, British Metals 17% each; Western Metals 8.5%; Bretton Investments 5.1%; Electro-Kopper 12%; Bahrain Government 40.4%.
China, People's Republic of:		Government 100%.
Fushun, Kiaoning	60	
Taiyuan, Shansi; Lanchow, Kansu; Hefei, Anhwei; Changchun, Chilin; Tsingtao, Shantung; Jiaozuo, Honan; Wuhan, Hupei; Hunan, Hunan; Changsha, Hunan	160	
Total China, People's Republic of	220	
India:		
Aluminium Corp. of India Ltd. (Alucoin):		Self 100%.
Asansol, West Bengal	10	
Hindustan Aluminium Corp. Ltd. (Hindalco):		Kaiser 27%; Birla and Indian interests 73%.
Renukoot, Uttar Pradesh	105	
Indian Aluminium Co. Ltd. (Indal):		Alcan 65%; Indian interests 35%.
Belgaum, Bombay	73	
Alupuram, Kerala	21	
Hirakud, Orissa	25	
Madras Aluminium Co. Ltd. (Malco):		Montecatini Edison 27%; Madras State Government 73%.
Mettur India	20	
Total India	254	
Iran:		
Iran Aluminum Co. (IRALCO), Arak	50	Iranian Government 77.7%; Reynolds Metals Co. 17.3%; Pakistani Government 5%.
Japan:		
Mitsubishi Chemical Industries, Ltd.:		Self 100%.
Naoestu	170	
Sakaide	99	
Nippon Light Metal Co., Ltd. (NLM):		Alcan 50%; Japanese interests 50%.
Kambara	123	
Kokkaido (Tomakomai)	143	
Niigata	110	
Showa Denko K.K.:		Self 100%.
Chiba	185	
Kitakata	47	
Omachi	46	
Sumitomo Chemical Co., Ltd.:		Self 100%.
Isoura	84	
Kikumoto	26	
Nagoya	176	
Toyama	176	
Mitsui Aluminium Industry Co., Omuta	85	Self 100%.
Total Japan	1,356	
Korea, South:		
The Daehan Aluminum Co. (Han Kuk):		Korean Development Bank 50%; PUK 50%.
Ulsan	18	
Taiwan:		
Taiwan Aluminium Corp. (Taialco):		Government 100%.
Kaohsiung, Takao	42	
Turkey:		
Seydisehir	22	Government 100%.
Total Asia	2,094	

Table 17.—World producers of primary aluminum—Continued
(Thousand short tons)

Country, company, plant location	Capacity, yearend 1973	Ownership
OCEANIA		
Australia:		
Alcan Australia, Ltd.:		Alcan 70.5%; other interests 29.5%.
Kurri-Kurri, New South Wales	50	
Alcoa of Australia Pty. Ltd.:		Alcoa 51%; Australian interests 49%.
Point Henry, Victoria	99	
Comalco Industries Pty. Ltd.:		Kaiser 45%; Conzinc Rio Tinto of Australia Ltd. 45%; other Australian interests 10%.
Bell Bay, Tasmania	104	
Total Australia	253	
New Zealand:		
New Zealand Aluminium Smelters Ltd.:		Comalco Industries, Pty. Ltd. 50%; Sumitomo Chemical Co. 25%; Showa Denko K.K. 25%.
Bluff	123	
Total Oceania	376	
Total world	15,041	

scheduled to be increased to 36,000 tons per year by 1974. The planned expansion would bring total capacity in Brazil at existing plants to about 200,000 tons per year by 1976.

A proposed new plant to produce primary aluminum near Recife and at other locations was being planned by Brazilian, Canadian, and Japanese interests in connection with the development of the Trombetas bauxite deposits. Total domestic production capacity for primary aluminum was expected to reach 300,000 to 400,000 tons per year by the 1980's.

Canada.—Alcoa announced plans to construct a 60,000-ton-per-year primary aluminum plant near Valleyfield, Quebec, by 1976. Alcan reportedly had flexible plans to add 300,000 tons of new or expanded capacity in Canada over the next 10 years. The company was considering construction of a 90,000-ton-per-year primary aluminum plant in the Saguenay-Lac St. Jean area of Quebec for possible completion in 1977, was scheduled to boost annual productive capacity at its Arvida plant by 38,000 tons in 1976, and reportedly was discussing, with NLM, a 50% owned company based in Japan, the possibility of expanding existing Canadian capacity or of constructing new primary aluminum facilities in Canada.

China, People's Republic of.—Based on a published report, primary capacity at the Fushun plant was about 60,000 tons per year. The plant was said to be operated efficiently and possibly to be using alumina from the aluminous shales near Kiaoning.[5] Strong demand for primary aluminum apparently continued since imports were established to have been in the 100,000-ton-per-year range, the same as last year. Reportedly, more metal would have been purchased if prices had been lower.

Czechoslovakia.—Primary aluminum capacity was expected to be increased to 132,000 tons per year by the 1980's.

France.—The primary aluminum plant at Nogueres was shut down from June 27 to August 16 because of a dispute between management and workers. The electrolyte and molten metal left in the cells froze, and production was not resumed until September. By yearend about 90% of the plant was believed to be operating. Some 40,000 tons of production was said to have been lost, and possible damage to anodes caused by the freezing of the cells had not been fully assessed.

Germany, Federal Republic of.—The 88,000-ton-per-year alumina reduction plant at Stade, operated by Vereinigte Aluminium-Werke A.G. (VAW) was commissioned. Commercial production also was being started at the new 110,000-ton-per-year primary aluminum facility at Hamburg, operated by Reynolds.

Greece. — The Government and Alcoa reached agreement in principle to construct a $350 million alumina-aluminum complex at Pachi, near Megara. The facility will include a 286,000-ton-per-year primary aluminum production plant which is to become

[5] Mamen, C. China Report—Part 2. Mines and Plants Visited. Canadian Mining J., v. 94, No. 3, March 1973, p. 33.

operational in two stages. The first stage was expected to be operating by 1976, and the second by 1978 or 1979. Share capital investment was to be $105 million, 60% by Alcoa and 40% by the Government through the Hellenic Industrial Development Bank, which also was to arrange for loans to raise the remaining $245 million.

Hungary. — Government spokesmen reportedly announced plans to expand primary aluminum capacity from about 69,000 tons per year in 1973 to 96,000 tons per year by 1985. Fabricating capacity during the same period was expected to be increased to between 270,000 and 300,000 tons per year, compared with about 100,000 tons per year in 1973. Primary aluminum requirements were received from the U.S.S.R. under barter arrangements in exchange for alumina produced in Hungary.

India.—The capacity data shown in table 17 include some expansions believed to have been completed in 1972 or 1973 but not operated during 1973 because of an electric power shortage. The Madras Aluminium Co. Ltd. (Malco), Hindustan Aluminium Corp. Ltd. (Hindalco), and Indian Aluminium Co. Ltd. (Indal), were especially affected by the power shortage. Because of the energy problems, total output of primary aluminum was curtailed during the year. The Tamil Nadu government announced plans to nationalize Malco.

Indonesia.—The government and five Japanese aluminum companies apparently agreed in principle to build hydroelectric power and primary aluminum production facilities costing $500 million at Kuala Tanjung on the east coast of Northern Sumatra. Alcoa and Kaiser participated at various times in the preliminary discussions of the project and reportedly were still considering plans to join the Japanese firms, which included Mitsui Aluminum Industry Co., Ltd., Mitsubishi Chemical Industries, Ltd., NLM, Showa Denko K.K., and Sumitomo Chemical Co., Ltd. The primary aluminum plant was scheduled to have an initial capacity of 250,000 tons per year beginning in the early 1980's and eventually be expanded to 450,000 tons per year. The power facilities would have a 480,000-kilowatt capacity.

Although many details were yet to be agreed upon, the plan reportedly called for nationalization of the power facility 30 years after it was commissioned. The initial agreement also called for a fixed tax of $16.55 per short ton of aluminum produced plus a corporation tax on profits of 37.5% for the first 10 years and 45% thereafter.

Italy.—MCS S.p.A., owned by the State corporation Ente Participazione Finanziamento Industria Manifattura (EFIM), acquired 94% of the aluminum operations of Montecatini Edison S.p.A. MCS also started production of primary aluminum at a new plant at Porto Vesme in Sardinia.

Japan.—Primary aluminum capacities at Niigata, Chiba, and Toyama were expanded. Electric power supply problems and increased costs of imported oil threatened to cause production cutbacks at about half of the primary aluminum plants toward the end of the year. The increased fuel costs were expected to encourage the location of primary aluminum capacity outside Japan.

Korea, Republic of.—A new firm, the Daehan Aluminum Co., was formed by the Korean Development Bank and Péchiney Ugine Kuhlmann (PUK) to operate the primary aluminum plant at Ulsan. The plant was to be expanded to about 100,000 tons per year by 1978, at a cost of $88 million, about 20% of which was to be raised locally.

Netherlands.—Capacity of the Vlissingen primary aluminum plant operated by the PUK Group was expected to be doubled early in 1974. Pending availability of electric energy, a third potline, increasing capacity to 278,000 tons per year, was expected to be constructed by 1977.

Norway.—Subject to availability of electric power, market conditions, and financial arrangements. A/S Ardal og Sunndal Verk (ASV) planned to increase primary aluminum capacity at its Ardal plant to 215,000 tons per year by 1980. The 33,000-ton-per-year plant at Hoyanger would be dismantled after a new 110,000-ton-per-year facility is started up in 1981. The Sunndal plant was to be expanded to 200,000 tons per year by 1980. Det Norske Nitridaktieselskap (DNN) planned to phase out its primary aluminum plant at Eydehavn in 1974, and was considering expansion of capacity at its Tysseldal plant to 50,000 tons per year. Lista Aluminiumverk A/S (Elkem) also was considering expansion of its primary aluminum plant to 88,000 tons per year by 1975.

New Zealand.—New Zealand Aluminium Smelters Ltd., planned to expand capacity of its Bluff primary aluminum plant to 166,000 tons per year by 1976. Government restrictions, placed on the level of Lake Manapouri, the source of electric power for the plant, appeared to limit the ultimate capacity of the facility, which had previously been scheduled to reach 250,000 tons per year.

Philippines.—Tentative plans for construction of two primary aluminum plants were reported. Reynolds International Inc., a subsidiary of Reynolds Metals Co. of the United States, and the Government signed a letter of intent to construct, near Ormos, Leyte, a 100,000-ton-per-year aluminum plant in which each will hold a 50% interest. Reynolds was to manage construction and provide technical assistance for the project. Implementation of the plans apparently was contingent on whether sufficient sources of geothermal power could be found.

Alusuisse reportedly was selected to supply the technical knowhow for a proposed new 22,000-ton-per-year primary aluminum facility in Mindanao, planned by the Aluminum Corp. of the Philippines.

South Africa, Republic of.—Capacity of the primary aluminum plant at Richards Bay was expected to be expanded to 84,000 tons per year in 1974.

Spain.—An agreement in principle was reached between Alcan, PUK, the Government entity, and the Instituto Nacional de Industria (INI), for the formation of a new corporation to produce alumina and primary aluminum metal at Villagarcía de Arosa in Galicia. Empresa Nacional del Alumínio S.A. (ENDASA), 50.5% of which was owned by INI, a government corporation, would own 50.5% of the new organization, Alcan would hold 25%, and the remainder would be held by Aluminio de Galicia, S.A. (Alugasa), which in turn is owned 66% by PUK, and 34% by Spanish interests.

Projected capacity of the primary aluminum plant, scheduled to be in operation in 1977, was 193,000 tons per year. Alumina was to be supplied from a domestic plant using Brazilian bauxite. Electric power would be based on lignite and would be supplied by the Puentes de Garcia Rodriquez generating plant.

Turkey.—Production was started at the primary aluminum plant at Seydisehir early in the year. Initial capacity was estimated at about 22,000 tons per year and was to be increased eventually to 66,000 tons per year.

U.S.S.R.—PUK reportedly was discussing plans to provide technical assistance for building a $500 million primary aluminum plant near the Syano-Shushenska hydroelectric facilities under construction in the Yenissey-Ankara River Basin in Siberia. Production at the planned 500,000-ton-per-year aluminum plant was expected to begin after initial operation of the hydroelectric facilities in 1977.

Venezuela.—Plans for major expansion of domestic primary aluminum capacity were announced. The capacity of the existing primary aluminum plant at Matanzas was being doubled to 50,000 tons per year. Mitsubishi Chemical Industries, Ltd., and other Japanese firms, and Reynolds, half owner of the Matanzas plant, were discussing plans for a new plant or an additional expansion to 200,000 tons per year. In addition, three Japanese firms, Showa Denko, K.K., Kobe Steel Co., and Marubeni, K.K., and the Corporación Venezolana de Guyana (CVG) a government agency, formed a new company, Industria Venezolana de Aluminio C.A., to construct a 75,000-ton-per-year primary aluminum plant by 1977, which was scheduled to be doubled by 1979. Showa Denko and Kobe Steel would each own 35% of the new company. Marubeni would own 10%, and the CVG would own the remaining 20%.

Yugoslavia.—Production reportedly was started at the new 83,000-ton-per-year primary aluminum plant at Sibenik. Electric power for the plant apparently was limited, restricting output. Capacity reportedly was scheduled to be increased to 110,000 tons per year by 1976. Despite the apparent problems with electric power supply, expansion of the capacity of the Titograd primary aluminum plant also was planned.

TECHNOLOGY

The trend toward automation of primary aluminum production facilities through computerization continued. Showa Denko K.K. of Japan found that computer-controlled, high-ampere (150,000 ampere), large-sized, prebaked aluminum potlines were generally more efficient than other types, although cathode wear was somewhat higher owing to the high amperage.[6] The new line was especially designed to reduce labor and power requirements.

Computerized, automated feeding of alumina to reduction cells at the ASV primary aluminum plant at Sunndal, Norway was tested.[7] Two groups of reduction cells each with 11 cells, were used in the test. Alumina was added to the cells in one of the groups in sufficient quantities to establish stability in the cells, following each "anode effect" or period of time during which the voltage across the cell increases sharply, indicating a depletion of alumina in the bath. The other group was supplied a specific constant quantity of alumina after each anode effect and feeding cycle. The group with interim alumina additions based on an assumed interval of 24 hours between anode effects, consumed less power and fluoride, and the anode effects were easier to control. Under these conditions about one anode occurred in each cell per day. By extending the assumed anode effect to 48-hour intervals, the actual anode effects were reduced to 0.6 per day.

Commercial operating experiences with the National Southwire Aluminum Co. computer-controlled alumina reduction plant at Hawesville, Ky.,[8] and at Intalco's Ferndale, Wash.,[9] plant were described. The experimental computer-controlled operation of 20 reduction cells at the Granges Aluminum Co. reduction plant at Sundsvall, Sweden was described in detail.[10] Granges planned to install a $1 million computer control system at its plant during 1973 and 1974.

The Bureau of Mines published two reports on its investigations of methods to recover aluminum and other metals from wastes and scrap.[11]

The Bureau operated a 5-ton-per-hour pilot plant for continuous mechanical separation of values contained in raw urban refuse. The entire system was assembled using commercially available equipment. The process relies on multistage processing including shredding, air classification, screening, gravity concentration, and electrostatic separation. Compactor trucks delivered raw refuse collected along typical routes in metropolitan Washington, D.C., to the pilot plant. The loads were separated into concentrates of (1) light-gage iron, (2) massive metals, (3) glass, (4) putrescibles and waste combustibles, (5) paper, and (6) plastics. Although some refinements remain to be made in the processing system flowsheet, the data obtained to date were highly encouraging, indicating favorable economics for commercial-size plants.

Three cryogenic methods were investigated in conjunction with crushing and classifying techniques to separate and reclaim the metallic components contained in insulated wires, shredded automobile nonferrous metal concentrates, small motors, generators, and rubber tires. Excellent separation of zinc die-casting alloys from copper and aluminum contained in shredded automobile nonferrous metal concentrates was attained by chilling at −72° C for 1 minute, crushing in a grateless hammer mill, and screening. From the screened products, 97.2% and 100% of the copper and aluminum, respectively, were recovered in the plus 1-inch fraction, and 100% of the zinc was recovered in the minus 1-inch fraction of over 97% zinc die-cast purity. Laboratory experimental results comparing direct and indirect chilling indicated that a sufficiently

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[6] Rutledge, P. Showa Denko Launches Automated Potline Using Prebaked Anodes at Chiba Aluminum Smelter. Eng. and Min. J., v. 174, No. 10, October 1973, pp. 88–90.

[7] Lindheim, O., and O. Mandal. Computerized Control and Wheelbreaker Operation of Aluminum Reduction Cells. Pres. at 102nd Ann. Meeting, Light Met. Soc., AIME, Proc., Chicago Ill., Feb. 25–Mar. 1, 1973, pp. 11–26.

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[9] Dugois, J., J. Ganii and K. Williams. Analysis of Intalco Aluminum's Potline Minicomputers. Pres. at 102nd Ann. Meeting, Light Met. Soc., AIME, Proc., Chicago, Ill., Feb. 25–Mar. 1, 1973, pp. 159–174.

[10] Bohlin, U. Computer Control of Aluminum Electrolysis at Granges Aluminum Employing 'Normalized Voltage'. Pres. at 102nd Ann. Meeting, Light Met. Soc., AIME, Proc., Chicago, Ill., Feb. 25–Mar. 1, 1973, pp. 39–56.

[11] Sullivan, P. M., M. H. Stanczyk, and M. J. Spendlove. Resource Recovery From Raw Urban Refuse. BuMines RI 7760, 1973, 28 pp.
Valdez, E. G., K. C. Dean, and W. J. Wilson. Use of Cryogens to Reclaim Nonferrous Scrap Metals. BuMines RI 7716, 1973, 13 pp.

low temperature could be attained by indirect chilling to permit use of a liquid CO_2-dry ice system on insulated wires and mixed nonferrous metallic concentrates.

Other industry developments in processing scrap materials included development of an air classifier system, which reportedly enabled the production of high-quality fuel from the lightweight part of shredded trash and enhanced recovery and recycling of metals and other heavy material.[12] In the system, garbage is shredded into small pieces and introduced into the air classifier. Air is drawn upward through the material causing separation of the solid waste into light and heavy fractions. A series of magnetic belts are used to separate the ferrous products from the other heavy components. Using the system, American Can Co. proposed a full system for treating a municipality's solid waste—erecting a treatment facility, operating and managing it, marketing recoverable materials, and disposing of unsalable residues. The system was proposed in several major metropolitan areas.

Cryogenics Inc., reportedly was expanding a large-scale pilot plant operation utilizing a nitrogen freezing method to generate 50 tons per day of clean aluminum, steel, copper, and precious metals from conglomerate scrap.[13] After nitrogen freezing, aluminum, copper, and steel-bearing motors were processed in hammer mills, shaker screens, and air and magnetic separation equipment.

Increasingly stringent restrictions on the emission of pollutants and the continuing cost-price squeeze in production of primary aluminum has resulted in intensified efforts to reduce fluorine consumption. The quantities of fluorine used, the reasons for the losses, and the trends in consumption of fluorine including a forecast of use to 1980, were dicussed.[14]

Methods for controlling fumes released when magnesium is removed from molten aluminum were described in proposed rules for effluent guidelines for the secondary aluminum industry.[15] Wet scrubbing techniques in effect transfer an air pollution problem to a water pollution problem whether chlorine or aluminum fluoride are used to remove the magnesium. Water from fume scrubbing techniques is neutralized to precipitate aluminum and magnesium compounds and the supernatant water is recycled.

Dry processes must contend with corrosive gasses in both methods for removing magnesium. In the Derham process, which has been licensed for use at about five plants in the United States, magnesium chloride is entrapped in a liquid flux covering the molten aluminum in a special compartment.[16] The resulting flux is reused in melting operations. The Alcoa process is a fumeless process for removing magnesium from molten aluminum and recovers magnesium chloride as a product. This process uses no flux and achieves high chloride efficiency through extending the time of contact between chlorine and magnesium in the melt. In the coated baghouse or Teller technique, the fumes resulting from magnesium removal are passed through filter bags coated with a solid material to absorb effluent gasses as well as to retain particulates.

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[12] American Metal Market. Rights to Air Classifier System For Solid Waste to Americology. V. 80, No. 221, Nov. 14, 1973, p. 14.

[13] Bohne, W. Cryogenics So Successful Quadrupling of Pilot Plant Targeted For Next March. Am. Metal Market, v. 80, No. 216, Nov. 7, 1973, pp. 11, 16.

[14] Wickes, H. G., Jr., and J. B. Whitchurch. Fluorine Consumption Trends of the Aluminum Industry. Pres. at 102nd Ann. Meeting, Light Met. Soc., AIME, Proc., Chicago, Ill., Feb. 25–Mar. 1, 1973, pp. 1–21.

[15] Environmental Protection Agency. Nonferrous Metals Manufacturing Point Source Category. Federal Register, V. 88, No. 30, 1973, pp. 33169–33183.

[16] Derham, Leslie J. (assigned to Alloys and Chemicals Corp.). Purification of Aluminum. U.S. Pat. 3,650,730, Mar. 21, 1972.

Antimony

By Charlie Wyche [1]

Responding to a generally tight supply and increasing demand, the domestic antimony industry increased both mine and primary smelter production during 1973. Increases were also recorded in both consumption and secondary smelter production. The 28% increase in consumption of primary antimony was balanced by withdrawals from the U.S. stockpile as imports of ore, metal, and oxide decreased from those of 1972. Byproduct antimonial lead at primary lead refineries increased 56%. Secondary smelters operated at a high rate throughout the year, and production of antimony from scrap increased 3% over that of 1972. The domestic primary metal price rose from $0.59 per pound in January to $0.94 in mid-December. Consumer stocks of primary antimony increased about 1,500 tons during the year.

Legislation and Government Programs.—The General Services Administration (GSA) as authorized under Public Law 92–105, enacted August 11, 1971, continued disposal of some 6,000 tons of surplus Government stocks of antimony metal. The metal was in the form of granules, pigs, slabs, cakes, and ingots, and was of stockpile grades "C" and "D" quality. Initially, the rate of disposal was set at 800 tons per calendar quarter; however, this was increased in May to more than 2,000 tons per quarter. In late November, GSA had exhausted that portion of its stocks that Congress authorized it to sell. Since the stockpile metal was less pure than the two commercial grades, GSA prices were lower than commercial prices. The quoted price range of GSA for grade "C" metal rose to $0.68 per pound, from $0.62 at the beginning of the year. Purchasers had to agree that the antimony was for domestic consumption. Firms that purchased antimony for resale had to agree to sell the metal at no more than the price charged by GSA. Total sales from Government stocks in 1973 amounted to 5,975 tons; Government inventory at yearend was 40,702 tons.

Exploration assistance for antimony continued under the Office of Minerals Exploration, and Government participation remained at 75%.

[1] Physical scientist, Division of Nonferrous Metals—Mineral Supply.

Table 1.—Salient antimony statistics

(Short tons)

	1969	1970	1971	1972	1973
United States:					
Production:					
Primary:					
Mine	938	1,130	1,025	489	545
Smelter [1]	13,203	13,381	11,374	13,344	17,206
Secondary	23,840	21,424	20,917	r 22,428	24,062
Exports of ore, metal, alloys	207	543	1,023	121	515
Imports, general (antimony content)	17,032	18,654	13,595	23,743	21,265
Consumption [1]	17,843	13,937	13,707	16,124	20,613
Price: New York, average cents per pound	57.57	144.19	71.18	59.00	68.50
World: Production	73,001	77,124	r 70,653	73,259	76,419

r Revised.
[1] Includes primary antimony content of antimonial lead produced at primary lead refineries.

DOMESTIC PRODUCTION

MINE PRODUCTION

Domestic mine production of 545 tons of antimony in 1973 was 11% above that of 1972, reversing the downward trend, which began in 1971. Production of antimony from antimony ores increased in relation to that from other sources, but antimony recovered as a byproduct of lead-silver ores by the Sunshine Mining Co. remained the predominant source of mine production. The lead-silver ores of the Coeur d'Alene district of Idaho contributed 322 tons (59%) of the total supply. Production would have been even higher if a 4-month strike had not occurred at the company's Kellogg, Idaho, plant.

U.S. Antimony Corp., the only U.S. mine that operated primarily for antimony, increased its metal production substantially during the year. Although the smelter began operating on a regular basis in the spring of 1973, there were still some metallurgical problems to be solved at yearend. The operation is a batch process and has a capacity of approximately 600 tons of metallic antimony annually. A planned 50% increase in mill output is expected to increase metal production to about 800 tons per year. The company is also studying the feasibility of producing antimony trioxide.

The only other source of domestic mine production was a mine in Nevada. In addition, 731 tons of antimony was recovered in antimonial lead from domestic lead ores at primary lead smelters.

Table 2.—Mine production and shipments of antimony in the United States

(Short tons)

Year	Antimony concentrate (quantity)	Antimony Produced	Antimony Shipped
1969	5,707	938	943
1970	6,681	1,130	1,029
1971	4,721	1,025	1,073
1972	2,072	489	547
1973	2,468	545	494

SMELTER PRODUCTION

Primary.—Primary smelter production of antimony was 17,206 tons, an increase of 29% over that produced in 1972. The increase resulted essentially from higher output of oxide, byproduct antimonial lead, and residues. However, production of metal and sulfide decreased 25% and 60%, respectively. The antimony content of byproduct antimonial lead recovered at primary lead refineries from domestic and foreign ores increased to 1,143 tons, 56% above that of the previous year. Ores and concentrates used by primary smelters to produce metal was derived from the following: 92% from foreign antimony ores and base metal ores, and 8% from domestic mine production of antimony concentrate and as a byproduct at domestic lead smelters. Most of the byproduct antimony recovered was consumed at the smelter in the manufacture of antimonial lead; the remainder was processed to oxide or recycled in residues.

The quantities and types of material produced at the smelters were as follows: Metal, 16%; oxide, 65%; antimonial lead, 7%; ground residue, 11%; and sulfide, 1%. Antimony metal was produced by NL Industries, Inc., Sunshine Mining Co., and U.S. Antimony Corp. Oxide was produced by American Smelting & Refining Co., Harshaw Chemical Co., McGean Chemical Co., M & T Chemicals Inc., NL Industries, Inc., and U.S. Antimony Corp. Byproduct antimonial lead was produced at lead refineries operated by American Smelting & Refining Co., The Bunker Hill Co., and St. Joe Minerals Corp.

Secondary.—Recovery of antimony from antimonial lead scrap totaled 24,062 tons, a 7% increase from 1972. The overall rise was attributed to the increased availability of old antimonial lead scrap. Secondary smelters recovered 20,459 tons, primary smelters recovered 24 tons, and manufacturers and founderies recovered the remaining 3,579 tons. Old scrap represented 85% of the total secondary antimony produced and consisted of the following: Batteries, 66%; type metal, 14%; babbitt, 12%; and all other material, 8%. Drosses and residues were the only sources of secondary antimony recovered from new scrap, which contributed 15% of the total. The antimony content of antimonial lead recovered from secondary sources was normally insufficient to meet commercial specifications of antimonial lead alloys. To prepare the desired alloys, about 2,275 tons of primary antimony was required to supplement the secondary antimony during 1973, compared with 2,570 tons in 1972.

Table 3.—Primary antimony produced in the United States
(Short tons, antimony content)

Year	Class of material produced					Total
	Metal	Oxide	Sulfide	Residues	Byproduct antimonial lead	
1969	3,129	7,746	95	330	1,903	13,203
1970	3,732	8,261	23	384	981	13,381
1971	3,816	6,272	18	136	1,132	11,374
1972	3,837	8,343	232	201	731	13,344
1973	2,859	11,273	92	1,839	1,143	17,206

Table 4.—Secondary antimony produced in the United States, by kind of scrap and form of recovery
(Short tons, antimony content)

Kind of scrap	1972 r	1973
New scrap:		
Lead-base	3,622	3,527
Tin-base	65	62
Total	3,687	3,589
Old scrap:		
Lead-base	18,725	20,459
Tin-base	16	14
Total	18,741	20,473
Grand total	22,428	24,062

Form of recovery	1972 r	1973
In antimonial lead [1]	17,452	19,212
In other lead alloys	4,970	4,842
In tin-base alloys	6	8
Total	22,428	24,062
Value (millions)	$26.5	$33.0

r Revised.
1 Includes 319 tons of antimony recovered in antimonial lead from secondary sources at primary plants in 1972 and 24 tons in 1973.

Table 5.—Byproduct antimonial lead produced at primary lead refineries in the United States
(Short tons)

Year	Gross weight	Antimony Content				
		From domestic ores [1]	From foreign ores [2]	From scrap	Total	
					Quantity	Percent
1969	24,741	1,174	729	179	2,082	8.4
1970	20,438	598	383	203	1,184	5.8
1971	19,686	828	304	59	1,191	6.0
1972	15,051	516	215	319	1,050	7.0
1973	15,455	731	412	24	1,167	7.6

1 Includes primary residues and a small quantity of antimony ore.
2 Includes foreign base bullion and small quantities of foreign antimony ore.

CONSUMPTION AND USES

Total domestic consumption of primary and secondary antimony in 1973 was 44,675 tons, 13% greater than that of 1972. Primary antimony contributed 46% of the total (20,613 tons), and secondary metal supplied 54% (24,062 tons). Virtually all of the secondary antimony was consumed in the manufacture of antimonial lead grids for use in batteries and other hard-lead alloys.

Industrial usage of primary antimony by class of material consumed increased in all areas except ore and concentrate. In the category of consumption by products, the use of metal decreased in all products except antimonial lead, ammunition, castings, and solder. Antimony metal and antimony oxide represented 45% and 55%, respectively, of the raw material consumed. Total consumption of primary metal products increased 26%, resulting principally from increased usage for antimonial lead.

Table 6.—Industrial consumption of primary antimony in the United States

(Short tons, antimony content)

Year	Class of material consumed						
	Ore and concentrate	Metal	Oxide	Sulfide	Residues	Byproduct antimonial lead	Total
1969	507	6,275	8,756	72	330	1,903	17,843
1970	380	4,989	7,157	46	384	981	13,937
1971	387	5,080	6,944	28	136	1,132	13,707
1972	1,226	5,473	8,389	104	201	731	16,124
1973	582	5,824	10,970	255	1,839	1,143	20,613

In nonmetal products, a substantial growth rate of antimony oxide usage was experienced in the area of flame retardants. Oxide consumption was given an even greater impetus by Government legislation requiring that the interior trims of 1973 model cars be treated with flame retardants. Since this requirement applied also to imported cars, the upsurge in demand for antimony oxide was noticeable throughout the world. Domestic consumption in ceramics and glass also continued the upward trend. A total of 2,219 tons of antimony was consumed in "other" nonmetal products. Of this quantity, approximately 73% was used as sodium antimonate as an opacifier in enamel frit. An additional 14% of this total was consumed as antimony trichloride, petroleum additives, antimony sulfide, and chemicals in a variety of applications.

Table 7.—Industrial consumption of primary antimony in the United States, by class of material produced

(Short tons, antimony content)

Product	1969	1970	1971	1972	1973
Metal products:					
Ammunition	115	102	67	64	122
Antimonial lead	6,723	5,246	5,430	6,149	8,027
Bearing metal and bearings	758	481	515	559	527
Cable covering	55	38	36	19	12
Castings	33	16	20	39	65
Collapsible tubes and foil	56	35	22	20	12
Sheet and pipe	105	77	74	108	97
Solder	242	286	178	177	191
Type metal	541	220	177	142	134
Other	137	73	102	105	104
Total	8,765	6,574	6,621	7,382	9,291
Nonmetal products:					
Ammunition primers	37	27	23	23	18
Fireworks	30	17	4	4	5
Flameproofing chemicals and compounds	2,096	1,774	1,524	2,280	2,906
Ceramics and glass	2,108	1,820	1,840	1,695	1,917
Pigments	722	610	592	644	644
Plastics	2,558	1,667	1,810	2,391	2,920
Rubber products	433	519	525	587	693
Other	1,094	929	768	1,118	2,219
Total	9,078	7,363	7,086	8,742	11,322
Grand total	17,843	13,937	13,707	16,124	20,613

STOCKS

Industry stocks were down in the second quarter, but increased steadily in the final quarters to 10,078 tons at yearend, the largest quantity on record. The increase was due primarily to the sale and delivery of about 5,000 tons of Government stocks to purchasers during the year. Increases in metal and ore stocks more than offset the decline of about 1,100 tons in oxide stocks. Stocks of residues and antimonial lead were substantially above the 1972 level. Antimony sulfide was the only other stock that was below the 1972 figure.

Government stocks of antimony on December 31, 1973, totaled 42,591 tons. Of the total inventory, the strategic stockpile contained 20,560 tons, and the supplemental stockpile contained 22,031 tons.

Table 8.—Industry stocks of primary antimony in the United States, December 31

(Short tons, antimony content)

Stocks	1969	1970	1971	1972	1973
Ore and concentrate	2,227	2,973	3,582	3,562	5,585
Metal	1,273	1,598	1,367	1,332	1,540
Oxide	2,053	2,932	2,697	3,179	2,074
Sulfide	108	39	22	182	31
Residues and slags	307	948	647	176	526
Antimonial lead [1]	371	357	322	191	322
Total	6,339	8,847	8,637	8,622	10,078

[1] Inventories from primary sources at primary lead refineries only.

PRICES

The domestic price for antimony metal increased four times during the year. The increases, which occurred in February, April, November, and December, raised RMM antimony metal from $0.57 to $0.92 per pound f.o.b. Laredo. The Lone Star grade increased from $0.68 to $1.09 per pound during the same period. The price increases took place in spite of the fact that GSA sold 5,947 tons of antimony metal in 1973. The price increases were attributed to the rapidly growing demand for antimony metal and compounds, particularly in flame retardants, and the reluctance of the People's Republic of China to sell any significant tonnages at its spring and fall Canton Fairs. Also, early in December, price decontrol for minor metals allowed U.S. antimony prices to aline with the generally higher prices in world markets. Prices for antimony trioxide also increased from $0.69 at the beginning of 1973, to $1.05 per pound by the close of 1973.

Strong demand for antimony metal and oxide during the year boosted the price of ore. The quoted price of European lump ore, 60% antimony, rose to $17.65–$18.65 per short ton unit, up from $7.60–$8.60 at the beginning of the year.

Table 9.—Antimony price ranges in 1973

Type of antimony	Price per pound
Domestic metal [1]	$0.57–0.92
Foreign metal [2]	.55–1.35
Antimony trioxide [3]	.69–1.055

[1] RMM grade, f.o.b., Laredo, Tex.
[2] Duty-paid delivery, New York.
[3] Quoted in Metals Week.

FOREIGN TRADE

Exports of antimony metal, alloys, and waste and scrap were 515 tons, appreciably above the 121 tons exported in 1972, and the value, $468,976, was more than five times that of the preceding year. Antimony scrap comprised the bulk of material exported, and consignments were made to 24 countries. Canada and Belgium were the leading importers with 79 tons each, followed by the United Kingdom. The oxide exported was 388 tons, 25% more than the 1972 total, with a value of $425,981 in 1973. West Germany, Canada, Brazil, and Belgium, in descending order of receipts, received over 73% of the total exports.

General imports of various antimony materials totaled 21,265 tons, a decline of 10% in comparison with 23,743 tons received in 1972. The decrease extended over all three categories of materials imported, but the largest decline was in receipts of metal. The Republic of South Africa, Bolivia, Mexico, Chile, and Turkey supplied over 90% of the ore and concentrate. Ten other countries supplied small percentages of the remainder. The People's Republic of China, the United Kingdom, and Mexico supplied over 65% of the metal. Yugoslavia, Belgium-Luxembourg, Brazil, Spain, and Turkey were the only other countries to supply any appreciable quantities of metal. Oxide deliveries came chiefly from the United Kingdom and France (77%).

Other imports included 100 tons of alloy containing 83% or more antimony, 57 tons of which came from the United Kingdom; 21 tons was received from Mexico; 20 tons was supplied by Belgium-Luxembourg, and 2 tons came from Canada. This material had a total value of $102,803.

Table 10.—U.S. imports for consumption of antimony, by country

Country	1972		1973	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Antimony metal including needle or liquated: [1]				
Belgium-Luxembourg	138	$135	61	$89
Brazil	55	50	33	20
Canada	1	15	1	24
China, People's Republic of	1,017	973	180	225
France	59	64	--	--
Germany, West	(2)	8	1	19
Hong Kong	66	65	--	--
Japan	86	103	3	4
Mexico	362	194	141	51
Netherlands	22	23	11	20
Singapore	5	5	--	--
Spain	12	13	34	55
Sweden	--	--	(2)	(2)
Taiwan	106	101	--	--
Turkey	37	30	32	36
United Kingdom	160	142	180	203
Yugoslavia	254	246	66	72
Total	2,380	2,167	743	818
Antimony oxide:				
Belgium-Luxembourg	610	651	410	557
Canada	--	--	3	5
China, People's Republic of	85	79	314	343
France	1,359	1,502	1,225	1,467
Germany, West	172	186	(2)	(2)
Japan	556	633	220	276
Netherlands	52	62	33	37
Taiwan	--	--	33	30
U.S.S.R.	--	--	45	57
United Kingdom	2,198	2,653	2,368	3,323
Total	5,032	5,766	4,651	6,095

[1] Includes needle or liquated (value in thousands) 1972: Belgium-Luxembourg, 73 tons ($68); United Kingdom, 5 tons ($7); 1973: Belgium-Luxembourg, 41 tons ($57); United Kingdom, 10 tons ($16).
[2] Less than ½ unit.

Table 11.—U.S. imports for consumption of antimony ore, by country

Country	1972			1973		
	Gross weight (short tons)	Antimony content (short tons)	Value (thousands)	Gross weight (short tons)	Antimony content (short tons)	Value (thousands)
Australia	56	34	$19	--	--	--
Bolivia	4,071	2,562	1,536	5,939	3,662	$2,807
Brazil	--	--	--	232	153	121
Canada	--	--	--	386	248	213
Chile	2,759	1,722	1,096	2,520	1,590	1,104
Colombia	--	--	--	111	52	11
Germany, West	57	25	15	--	--	--
Guatemala	315	158	35	586	296	82
Honduras	77	19	6	32	12	9
Iran	--	--	--	23	13	4
Mexico	8,261	2,217	820	7,099	2,088	563
Morocco	365	150	70	--	--	--
Mozambique	--	--	--	1,102	657	531
Peru	44	27	19	161	80	57
South Africa, Republic of	17,224	10,160	5,766	11,375	6,446	4,410
Thailand	313	138	55	88	36	19
Turkey	--	--	--	4,205	1,339	960
United Kingdom	--	--	--	10	7	12
Total	33,542	17,212	9,437	33,869	16,679	10,903

Table 12.—U.S. imports for consumption of antimony

Year	Antimony ore			Needle or liquated		Antimony metal [1]		Antimony oxide	
	Gross weight (short tons)	Antimony content (short tons)	Value (thousands)	Gross weight (short tons)	Value (thousands)	Gross weight (short tons)	Value (thousands)	Gross weight (short tons)	Value (thousands)
1971	22,102	9,619	$8,787	32	$47	1,638	$1,914	2,791	$4,317
1972	33,542	17,212	9,437	78	75	2,302	2,092	5,032	5,766
1973	33,869	16,679	10,903	51	73	692	745	4,651	6,095

[1] Does not include alloy containing 83% or more of antimony: 1971: United Kingdom, 120 short tons ($120,093); Turkey, 32 short tons ($29,022); Japan, 22 short tons ($18,453); Mexico, 85 short tons ($113,139); Thailand, 11 short tons ($10,356). 1972: Mexico, 87 short tons ($79,294); United Kingdom, 31 short tons ($25,327); Taiwan, 11 short tons ($31,693). 1973: United Kingdom, 57 short tons ($59,854); Mexico, 21 short tons ($19,858); Belgium-Luxembourg, 20 short tons ($20,216); Canada, 2 short tons ($2,875).

WORLD REVIEW

World primary antimony production, responding to favorable economic conditions, and escalating prices, increased 4% above that in 1972. Higher production rates, compared with 1972 were reported for most of the foreign countries, but only Bolivia, the Republic of South Africa, and Turkey had significant tonnage increases. Demand, however, exceeded supply in all major consuming countries. The Canton Fairs were of little help because the quantity of antimony supplied to the Japanese industry was small. Also, metal made available to the European market was at very high prices. Because of the unbalanced supply-demand relationship, antimony producers

Table 13.—Antimony: World production (content of ore unless otherwise indicated), by country

(Short tons)

Country	1971	1972	1973 p
North America:			
Canada [1]	162	340	947
Guatemala	976	992	1,060
Honduras	160	33	53
Mexico [2]	3,705	3,280	2,632
United States	1,025	489	545
South America:			
Argentina	15	23	e 30
Bolivia [3]	12,861	14,472	16,462
Peru (recoverable) [2]	r 757	881	e 900
Europe:			
Austria (recoverable)	515	553	636
Czechoslovakia e	660	660	660
Italy	1,295	1,324	1,510
Portugal	--	15	22
Spain	122	152	132
U.S.S.R. e	7,600	7,700	7,800
Yugoslavia	r 2,207	2,177	e 1,900
Africa:			
Algeria e	66	66	66
Morocco	2,174	917	1,249
South Africa, Republic of	15,704	16,062	17,306
Asia:			
Burma	141	144	158
China, People's Republic of e	13,000	13,000	13,000
Japan	3	e 6	e 6
Korea, Republic of	--	3	12
Malaysia (Sarawak)	317	226	e 220
Pakistan e	34	50	15
Thailand	2,529	5,208	e 3,750
Turkey	r 3,124	2,982	3,696
Oceania: Australia [4]	r 1,501	1,504	1,652
Total	r 70,653	73,259	76,419

e Estimate. p Preliminary. r Revised.
[1] Antimony content of smelter products; excludes output from New Brunswick, which is believed to be small.
[2] Includes antimony content of antimonial lead.
[3] Exports.
[4] Antimony content of antimony concentrates, lead concentrates, and lead-zinc concentrates.

worldwide continued to develop new mines and expand existing ones.

Australia.—Australia's Antimony Corp. N.L. reported that its antimony mine at Dorrigo, New South Wales, was brought into production in May. The company entered into an agreement with Broken Hill Antimony, Pty. Ltd. to process the ore. Broken Hill Antimony installed additional flotation facilities at the site to increase production to 4,000 tons of concentrate per year. Demand from buyers was heavy, and several offers of long-term contracts were considered. Proven ore reserves at Dorrigo exceeded 500,000 tons, and development work was being conducted in adjacent areas. The Antimony Corp. also has antimony prospects in the Taylor's Arm district near Macksville, New South Wales.

Munga Creek Minerals N.L. increased antimony ore production, despite rising production costs and the adverse affects of currency revaluations. The increased ore production (at the lease areas in the Kempsey district of New South Wales) and improved milling plant techniques will provide a continuous supply of antimony at lower prices to markets in North America, Europe, and Japan.

Atherton Antimony N.L. commenced opencut mining at the Antimony Reward mine in North Queensland. More than 9,000 tons of ore has been stockpiled, and exploration was continued to determine the extent of ore reserves. In Victoria, Mid-East Minerals N.L. continued underground development of the Brunswick Reef at Costerfield. Values of 20% to 30% antimony and up to 2.25 troy ounces of gold per ton have been reported in a vein 10 to 20 inches wide at a depth of 150 feet.

Bolivia.—Construction of an antimony smelter in Bolivia continued on schedule. This 5,000-ton-per-year smelter was expected to be completed during 1973. The Czechoslovakian firm, Skoda Export, carried out the feasibility study and helped to construct the $5 million smelter.

Burma.—In Burma, an antimony refining plant was constructed by the Mineral Development Corp. and was in operation near Moulmein.

Canada.—Consolidated Durham Mines & Resources Ltd. remained Canada's only antimony mine. The company mined vein-type ore deposits containing stibnite at its Lake George property near Fredericton, New Brunswick. The mill operated throughout 1973 after implementing a water pollution control system and undertaking additional shaft sinking and underground development in late 1972. The mill produced concentrates containing over 64% antimony, which was shipped to Japan, Europe, and the United States. Several other Canadian deposits of stibnite were explored and partly developed, but results were generally discouraging. The better known deposits were in the Atlantic Provinces, Quebec, British Columbia, and the Yukon Territory.

Japan.—Japan's Hibino Metal Co. made plans to import 40 to 50 tons of antimony metal on a long-term basis. Although the company presently produces a combined total of 300 tons of oxide and metal, it was reported that pollution controls, would prohibit expanded production from ore.

South Africa, Republic of.—In the Republic of South Africa, Chemetron Corp. (U.S. company) signed an agreement to form a joint venture company (Antimony Products (Pty.) Ltd.) to produce crude antimony oxide. The other participants were Consolidated Murchison Ltd. and Johannesburg Consolidated Investment Co. Ltd. Antimony Products Ltd. will build a plant near the antimony mines operated by Consolidated Murchison in the Northern Transvaal at Gravelotte, Republic of South Africa. The plant was scheduled for operation by the end of the year; annual capacity was to be around 3,500 tons.

Thailand.—A $1.2 million antimony mining and smelting project was in progress at Lampang Province (Northern Thailand) by Amco Metal Industries Corp. The annual capacity of the smelter will be 15,400 short tons of 99.8% metal. The new project will substantially enlarge the capacity of the country's antimony industry, which totaled 11,100 tons of ore and only 200 tons of metal in 1972. The additional tonnage will also alter somewhat the world production pattern and place Thailand among the top 10 antimony metal producers.

TECHNOLOGY

Two U.S. patents concerning the extraction of antimony metal and compounds were issued during the year. One patent, issued to the Federal Bureau of Mines, covers a method of producing hydrated antimony pentoxide electrolytically from either stibnite, tetrahedrite or livingstonite.[2] The ground ore concentrate was slurried in an aqueous brine of sodium chloride, potassium chloride, or potassium bromide, and the mixture electrolyzed at a temperature of not over 50° C and current density of from 0.1 to 1.0 ampere per square inch for a period of up to 24 hours, whereby the insoluble hydrated pentoxide was formed. The insoluble product was filtered off and converted to the metal by conventional procedures. The other patent described a method of processing antimony sulfide ore concentrate to obtain antimony oxide.[3] Flotation concentrate or other finely divided ore was fluidized with air or oxygen. The fluidized ore was heated to a temperature of 1,200–1300° C for a period of about 4 seconds under turbulent conditions, and the resulting antimony oxide was recovered from the kiln offgases.

An article[4] described how sintering of iron-antimony mixtures inhibit γ-grain growth as a result of the solid-phase diffusion of antimony in iron. When heated, the pellets of higher antimony contents exhibited a swelling that developed in one of two stages corresponding to the formation of intermetallic compounds.

A Canadian patent was issued pertaining to a process for removing antimony impurity from copper matte or copper sulfide.[5] The molten material was treated with scrap iron, and the treated melt partially oxidized with air or oxygen-enriched air to oxidize the scrap iron and cause the major portion of the antimony content to pass from the copper into the coverter slag.

[2] Schneiner, E. J., R. E. Lindstrom, and T. A. Henrie (assigned to the Department of the Interior). U.S. Pat. 3,755,106, Aug. 28, 1973.

[3] Nerazzi, N. (assigned to AMMI S.P.A.). U.S. pat. 3,759,500, Sept. 18, 1973.

[4] Behar, F., C. Servant, and G. Cizeron. Sintering in the System of Polyphase Mixtures of Pulverulent Iron and Antimony. J. Less-Common Metals, v. 30, No. 2, February 1973, pp. 259-278.

[5] Lundquist, S. A., (assigned to Boliden AB). Can. Pat. 930,959, July 31, 1973.

Asbestos

By Robert A. Clifton [1]

Shipments of asbestos in the United States increased 14% and established another record high in 1973. The construction boom was the main reason for the increased demand. Imports were 8% above 1972 levels.

Canada, the world's leading producer of asbestos increased shipments 7% to its largest market, the United States. Canada's total shipments increased 10% over those of 1972.

Legislation and Government Programs.—The Environmental Protection Agency (EPA) published asbestos emission standards in April. In October, EPA published the first portion of its effluent guidelines for asbestos manufacturing point sources. On April 16, 1973, in a Presidential message to the Congress proposing stockpile disposal legislation, the national stockpile objective for amosite was reduced to zero, and that of chrysotile to 1,100 short tons. In1973 the General Services Administration (GSA) reduced Government inventories by disposing of 419 short tons of amosite, 6,076 tons of crocidolite, and 266 tons of chrysotile. Rhodesian asbestos continued to arrive in the country under the "strategic material" exception in the U.S. observance of the United Nations sanctions.

Environmental Impact.—Threatened effects of environmental regulations on the asbestos market remained just threats in 1973. The new regulations of the Office of Safety and Health Administration (OSHA) of the Department of Labor did not slow asbestos use in manufacturing. EPA promulgated its regulations on asbestos dust on April 6.

The controversial Reserve Mining Co. case was still before the U.S. District Court in Duluth, Minn., at year-end. Appellate action was deemed likely whichever side won.

Energy.—The Bureau of Mines conducted a comprehensive study of energy use in the asbestos mining industry in 1973. The survey covered all producers in Arizona, California, North Carolina, and Vermont.

Sources of energy included 2.2 million gallons of heavy fuel oil (43% of total usage), 168 million cubic feet of natural gas (22%), 47.6 million kilowatt-hours of purchased electricity (21%), 545,000 gallons of diesel oil (10%), 182,000 gallons of liquefied petroleum gas (LPG) (3%) and 64,000 gallons of gasoline (1%). Converted

[1] Physical scientist, Division of Nonmetallic Minerals—Mineral Supply.

Table 1.—Salient asbestos statistics

	1969	1970	1971	1972	1973
United States:					
Production (sales) short tons	125,936	125,314	130,882	131,663	150,036
Value thousands	$10,648	$10,696	$12,174	$13,409	$16,288
Exports and reexports (unmanufactured) short tons	36,173	46,585	53,678	58,624	66,442
Value thousands	$4,979	$6,996	$7,863	$9,051	$9,342
Exports and reexports of asbestos products (value) thousands	$28,183	$25,391	r $31,409	$32,110	$40,720
Imports for consumption (unmanufactured) short tons	694,558	649,402	681,367	735,515	792,473
Value thousands	$76,422	$75,146	$80,090	$87,732	$98,914
Consumption, apparent [1] short tons	784,321	728,131	758,571	808,554	876,067
World: Production do	3,599,123	3,851,251	r 3,951,449	4,159,984	4,605,935

r Revised.
[1] Measured by quantity produced, plus imports (unmanufactured) minus exports and reexports (unmanufactured).

to equivalent kilowatt-hours, total energy used was 226 million kilowatt hours, of which 59 million (26%) was used in mining and 167 million (74%) in milling. On a tonnage basis, energy used per ton of usable asbestos was 1,500 kilowatt-hours. Estimated cost was $1.7 million or $11.32 per ton.

Table 2.—Analysis of U.S. asbestos production and trade
(As a percent of apparent consumption)

	1969	1970	1971	1972	1973
Mine production:					
Quantity	16	17	17	16	17
Value	13	14	14	14	15
Exports and reexports (unmanufactured):					
Quantity	5	6	7	7	8
Value	6	9	10	10	8
Imports for consumption:					
Quantity	89	89	90	91	90
Value	93	95	95	96	93
Net imports:					
Quantity	84	83	83	84	83
Value	87	86	86	86	85

Table 3.—Stockpile objective and Government inventories as of December 31, 1973
(Short tons)

	Stockpile objective	Inventories			
		National	Supplemental	Defense Production Act	Total
Amosite	--	11,630	46,549	--	58,179
Chrysotile	1,100	6,059	3,284	--	9,343
Subspecification	--	12	1,274	242	1,528
Crocidolite	--	1,554	17,814	--	19,368

Table 4.—Energy used by the asbestos mining industry in 1973

Source and unit	Used in mining	Used in milling	Total used	Total (thousand kilowatt-hours)
Heavy fuel oil thousand gallons	852	1,345	2,197	96,358
Natural gas million cubic feet	--	168	168	50,736
Electricity thousand kilowatt-hours	2,641	44,974	47,615	47,615
Diesel oil thousand gallons	412	133	545	22,147
LPG do	14	168	182	6,987
Gasoline do	52	12	64	2,343
Total energy, thousand kilowatt-hours	59,192	166,994	226,186	226,186

DOMESTIC PRODUCTION

U.S. mines shipped 14% more asbestos in 1973 than in 1972. The value increased 21%. Four States produced asbestos; California, with 70% was the leader, followed in order by Vermont, Arizona, and North Carolina. Total output was 150,036 tons valued at $16,288,000.

The California segment of the asbestos industry continued to grow, with a 16% increase in production to 105,663 tons, and was led by Pacific Asbestos Corp.'s mine in Calaveras County. The next leading producing county was Fresno, with Coalinga Asbestos Co. Inc. and Atlas Asbestos Corp. mines. Union Carbide Corp. had significant production in San Benito County. The State's increased production realized a $2,213,000 increase in value.

GAF Corp.'s mine in Orleans County, Vt., remained the asbestos mine in the

United States with the highest production, but was surpassed by Pacific Asbestos in product value. With only Jaquays Mining Corp.'s mine in Gila County operating in 1973, Arizona production decreased 27%. The production in North Carolina of Powhatan Mining Co. declined another 64% in 1973. U.S. asbestos producers and mine sites are as follows:

State and company	County	Name of mine	Type of asbestos
Arizona: Jaquays Mining Corp	Gila	Chrysotile	Chrysotile.
California:			
Atlas Asbestos Corp	Fresno	Santa Cruz	Do.
Coalinga Asbestos Co., Inc	do	Christie	Do.
Pacific Asbestos Corp	Calaveras	Pacific Asbestos	Do.
Union Carbide Corp	San Benito	Santa Rita	Do.
North Carolina: Powhatan Mining Co	Yancey	Hippy	Anthophyllite.
Vermont: GAF Corp	Orleans	Lowell	Chrysotile.

CONSUMPTION AND USES

Overall consumption in 1973 increased 8% over that of 1972 with no usage trends apparent.

The data shown in table 6 although collected on the same form as the 1972 data, are not really comparable with 1972 data because expansion of the mailing list resulted in a 17% increase in the share of apparent consumption reported by respondents. It appears however, for example, that the large increase in consumption shown by floor tile manufacturers was the result of better coverage rather than any great change in the market. The cooperation of the industry continued to result in more complete data. The chrysotile data in table 6 have been adjusted to reflect 96% of the apparent consumption. Data for other types of asbestos are presented as reported.

While continuity between 1972 data and those of 1973 is disclaimed in the preceding paragraph, the increase in consumption for minor or "Other" uses (to 22% of the total) is logical and can be explained as reflecting data from new respondents who have minor end uses. Of total consumption, the eight major uses were: Construction 30%, floor tile 20%, paper 10%, friction products 8%, asphalt felts 5%, packing and gaskets 2%, insulation 2%, and textiles 1%.

Analysis of the newly available data on U.S. asbestos consumption was facilitated by selectively grouping commercial chrysotile grades as shown in table 5. These selected groupings disregarded chemical and physical properties, etc., and are based loosely on the Quebec Asbestos Mining Association standards.

Crudes, and Groups 1, 2, and others, while not milled, have the same ultimate textile uses as Group 3, and will be grouped as "BM I," (spinning). Groups 4 and 5 will be "BM II," shingle and paper. Groups 6 and 7 will be "BM III," shorts.

Note that the spinning grades (BM I) are consumed only in four of the major

Table 5.—Bureau of Mines groupings of commercial chrysotile grades

BM I (spinning)	BM II (shingle and paper)	BM III (shorts)
CANADA		
Group 1 (crude), Group 2 (crude), Group 3, AAA, AA, A, AC, CC	Group 4, Group 5, AK, CP, AS, CT, AX, CY, AY	Group 6, Group 7
ARIZONA		
No. 1 Crude, No. 2 Crude, AAA	Group No. 3, Group No. 4, Group No. 5	Group No. 6, Group No. 7
CALIFORNIA		
None	Grade 4, Grade 5	Grade 6, Grade 7
VERMONT		
Grade 3	Grade 4, Grade 5	Grade 6, Grade 7, Grade 8

end uses, and comprised 2% of the reported tonnage consumed. Shingle and paper grades (BM II) comprised 20% of the weight of the fibers reported and were consumed in all the major use categories but floor tile and textiles. The remainder, 78% of the reported fibers were shorts (BM III) and were consumed in every major use except textiles.

The construction field accounted for 17% of the anthophyllite reported consumed with minor uses the remainder.

Eighty-four percent of the reported amosite consumption was used for insulation, 6% for construction, and 7% for asphalt felts.

Construction accounted for 50% of the crocidolite consumed and paper 1%.

A market survey made by a major inorganic fiber manufacturer, covering 1972 sales, distinguished between product categories and major consuming industry usage. This distinction between products and end uses was adhered to in this chapter.

Analysis of table 7 shows that although 100% of the obvious products were used in the construction industry, there were enough portions of other products used to show the construction industry accounting for 77% of the total asbestos consumption. This is probably high and caused in part by assigning all asbestos consumption to only three major industries. Another possible source of error can come from assigning no insulation (thermal or electrical) consumption to the transportation industry, because shipboard, train, and truck uses for insulation products are many.

The major industry breakdown of gaskets and packing, friction materials, coatings and compounds, and plastics are of interest.

An EPA report shows that nine of the major asbestos products manufacturing firms have captive fiber sources through United States and Canadian mines either wholly or partially owned. The total present production capacity of these mines exceeds 2 million short tons per year.

Table 6.—U.S. asbestos consumption in 1973

(Short tons)

End uses	Chrysotile (adjusted)				Anthophyllite (reported)	Amosite (reported)	Crocidolite (reported)
	BM I	BM II	BM III	Total			
Construction	--	99,900	148,400	248,300	193	275	9,029
Floor tile	--	--	172,700	172,700	--	--	--
Friction products	5,600	28,100	35,000	68,700	--	--	--
Paper	--	3,300	85,200	88,500	--	3	218
Asphalt felts	--	8,600	36,300	44,900	--	310	--
Packing and gaskets	1,200	10,700	9,600	21,500	--	--	56
Insulation	1,200	2,400	8,200	11,800	--	3,587	--
Textiles	10,900	--	--	10,900	--	--	29
Other	400	16,000	155,500	171,900	969	98	8,634
Total	19,300	169,000	650,900	839,200	1,162	4,273	17,966

Table 7.—Asbestos product industry distribution in 1972

(Thousand short tons)

Product	Market industry				
	Construction	Transportation	Appliance and equipment	Total	Percent of total
Asbestos cement pipe and sheet	217	--	--	217	26.8
Vinyl asbestos floor tile	152	--	--	152	18.7
Sheet vinyl flooring	96	--	--	96	11.8
Roofing papers	82	--	--	82	10.1
Gaskets and packing	10	25	35	70	8.6
Friction materials	--	60	8	68	8.4
Insulation, pipe and thermal	40	--	10	50	6.2
Coatings and compounds	23	5	5	33	4.1
Plastics	4	11	8	23	2.8
Electrical insulation	--	--	10	10	1.2
Export and reexport	--	4	4	8	1.0
Miscellaneous	--	1	1	2	.3
Total	624	106	81	811	100.0
Percent of total	77	13	10	100	

PRICES

Quoted prices for Quebec asbestos in 1973 rose 8%, effective May 1, 1973. British Columbia and Vermont asbestos prices remained unchanged. The price of all asbestos was expected to rise in the future.

Prices for some grades of Arizona chrysotile asbestos were raised on September 1, 1973. Quotations, f.o.b. Globe, were as follows:

Grade	Description	Per short ton
Group No. 1	Crude	$1,650
Group No. 2	do	950
AAA		853
Group No. 3	Nonferrous filtering and spinning	550– 700
Group No. 4	Nonferrous plastic and filtering	550– 600
Group No. 5	Plastic and filtering	385– 425
Group No. 6	Refuse or shorts	350
Group No. 7	do	65– 100

As of February 15, 1973, Vermont chrysotile asbestos, f.o.b. Morrisville, was priced as follows:

Grade	Description	Per short ton
Group No. 4	Shingle fiber	$218.00–371.00
Group No. 5	Paper fiber	157.50–185.00
Group No. 6	Waste, stucco, or plaster fiber	114.00
Group No. 7	Shorts and floats	43.50– 95.00

Quotations for Canadian (Quebec) chrysotile, f.o.b. mine, were as follows, as of May 1, 1973:

Grade	Description	Per short ton
Group No. 1	Crude	Can $1,745
Group No. 2	do	945
Group No. 3	Spinning fiber	445–730
Group No. 4	Shingle fiber	240–414
Group No. 5	Paper fiber	177–209
Group No. 6	Waste, stucco, or plaster	129
Group No. 7	Refuse or shorts	54–105

Prices for British Columbia, Canada, chrysotile asbestos were effective January 1, 1973. Quotations, f.o.b. Vancouver, were as follows:

Grade	Description	Per short ton
AAA	Nonferrous-spinning fiber	Can $895
AA	do	711
A	do	541
AC	Asbestos cement fiber	388
AK	Shingle fiber	276
CP	do	261
AS	do	240
CT	do	235
AX	do	219
CY	do	155
AY	do	155

Private negotiated sales are the African asbestos producers' modus operandi. Because this rules out market quotations, the following are average values, regardless of grade, imported from Republic of South Africa calculated from U.S. Department of Commerce data:

Type	Per short ton				
	1969	1970	1971	1972	1973[1]
Amosite	$153	$160	$164	$187	$187
Crocidolite	189	196	212	211	210
Chrysotile	192	198	120	202	260

[1] First 8-month data on imports, U.S. Bureau of the Census.

The increased demand for asbestos in all categories resulted in price increases almost across the board. Further price rises are expected early in 1974.[2]

[2] Asbestos. V. 55, No. 7, January 1974, p. 40.

FOREIGN TRADE

The value of exports of asbestos products manufactured in the United States increased 27% over the value of those exported in 1972. Six of the nearly 100 countries buying these products accounted for more than 60% of the foreign sales. They were Canada (40%), West Germany (8%), the United Kingdom (7%), Mexico (3%), Australia (3%), and Venezuela (1%).

The major products exported were packing and gaskets with 26% of the value, brake linings with 19%, and textiles and yarns 16%.

In 1973 the United States imported 90% of its crude asbestos needs. This was 1% below the 1972 percentage. Canada provided 96% of the imports, the Republic of South Africa provided 3%, and 13 other countries provided the remainder. Chrysotile, with 97%, dominated the imported types. There was a 13% increase in the dollar value of imported fibers.

Table 8.—U.S. exports and reexports of asbestos and asbestos products

Product	1972		1973	
	Quantity	Value (thousands)	Quantity	Value (thousands)
EXPORTS				
Unmanufactured:				
Crude and spinning and nonspinning fibers short tons	22,081	$3,786	42,791	$6,604
Waste and refuse do	29,711	3,835	23,109	2,647
Total do	51,792	7,621	65,900	9,251
Products:				
Gaskets and packing do	2,409	7,462	3,309	10,483
Brake linings do	4,496	6,654	5,813	7,863
Clutch facings, including linings number	2,727,573	1,908	2,620,486	1,870
Textiles and yarn short tons	8,643	4,863	9,598	6,454
Shingles and clapboard do	10,366	2,308	11,226	2,586
Articles of asbestos cement do	9,649	2,148	9,336	2,478
Protective clothing	NA	320	NA	462
Insulation, heat and sound	NA	1,772	NA	2,850
Manufactures, n.e.c	NA	r 4,623	NA	5,659
Total	--	32,058	--	40,705
REEXPORTS				
Unmanufactured:				
Crude and spinning and nonspinning fibers short tons	6,287	1,367	438	86
Waste and refuse do	545	63	104	5
Total do	6,832	1,430	542	91
Products:				
Gaskets and packing do	254	11	--	--
Textiles and yarn do	5	12	--	--
Articles of asbestos cement do	100	29	54	15
Total do	359	52	54	15

r Revised. NA Not available.

Table 9.—U.S. imports for consumption of asbestos (unmanufactured), by class and country

Year and country	Crude (including blue fiber) Quantity (short tons)	Crude Value (thousands)	Textile fiber Quantity (short tons)	Textile fiber Value (thousands)	All other Quantity (short tons)	All other Value (thousands)	Total Quantity (short tons)	Total Value (thousands)
1972								
Bolivia	29	$3	--	--	--	--	29	$3
Canada	66	10	11,599	$5,316	702,230	$78,577	713,895	83,903
Finland	--	--	--	--	2,243	160	2,243	160
Greece	--	--	--	--	6	1	6	1
Italy	--	--	--	--	2	3	2	3
Mozambique	428	85	--	--	597	118	1,025	203
Rhodesia, Southern	200	99	--	--	--	--	200	99
South Africa, Republic of	14,938	3,056	16	7	1,431	220	16,385	3,283
Swaziland	40	21	--	--	--	--	40	21
Switzerland	--	--	--	--	4	1	4	1
Yugoslavia	--	--	843	12	843	43	1,686	55
Total	15,701	3,274	12,458	5,335	707,356	79,123	735,515	87,732
1973								
Canada	1,991	397	15,665	6,020	746,988	86,449	764,644	92,866
Finland	--	--	--	--	1,027	93	1,027	93
Germany, West	79	21	--	--	--	--	79	21
Guyana	--	--	--	--	303	8	303	8
Italy	--	--	--	--	8	3	8	3
Malagasy, Republic	--	--	--	--	3	1	3	1
Mexico	--	--	--	--	43	7	43	7
Mozambique	51	27	--	--	5	1	56	28
Panama	--	--	--	--	12	11	12	11
Portugal	--	--	--	--	1	(1)	1	(1)
Rhodesia, Southern	845	423	--	--	--	--	845	423
South Africa, Republic of	21,629	4,510	8	1	3,427	733	25,064	5,244
Swaziland	200	122	130	73	--	--	330	195
Yemen	--	--	--	--	50	11	50	11
Yugoslavia	--	--	--	--	8	3	8	3
Total	24,795	5,500	15,803	6,094	751,875	87,320	792,473	98,914

1 Less than ½ unit.

Table 10.—U.S. imports for consumption of asbestos from specified countries, by grade

(Short tons)

Grade	1972 Canada	1972 Southern Rhodesia	1972 Republic of South Africa	1973 Canada	1973 Southern Rhodesia	1973 Republic of South Africa
Chrysotile:						
Crudes	66	200	2,439	1,991	845	1,235
Spinning fibers	11,599	--	16	15,665	--	8
All other	702,230	--	1,431	746,988	--	3,427
Crocidolite (blue)	--	--	5,374	--	--	12,552
Amosite	--	--	7,125	--	--	7,842
Total	713,895	200	16,385	764,644	845	25,064

WORLD REVIEW

All available information leads to the conclusion that 1973 was a record setting year for asbestos throughout the world. Demand, at least in the Non-Communist countries outstripped supply, as evidenced by the world's largest mine having its entire year's production sold by August. Market growth was limited by supply, but no real hardships surfaced, with the exception of spinning-grade fibers, which were in very short supply the latter part of the year.

The market situation, and worldwide inflation would indicate substantial price increases in 1974.

Australia.—The Woodsreef mine ran into trouble on two fronts. The revaluation of the Australian dollar decreased revenue at a time when equipment inadequacies would not permit increased production. New equipment eased the situation somewhat, but maybe not enough to reach the break-even point by the end of the year.

Bolivia.—A further influx ($658,000) of money was earmarked by the United Nations Industrial Development Organization (UNIDO) to the budding asbestos industry at Cochabamba. Corporacion Boliviana de Fomento was to contribute an additional $328,000 toward achieving a 5,000-ton-per-year operation there.

Canada.—For the second straight year Canadian production reached a record high, with a 17% increase over the previous year, and remains firmly in the lead as the worlds primary producer. A controversial proposal was put forward in Quebec to have the province's asbestos (80% of Canadian total) marketed through a provincial government "Development Council." The mining community reacted unfavorably. Major activity centered around the following:

1. Canadian Johns-Manville Co., Ltd. officially dedicated the new concentrator plant at its Jeffrey mine in Asbestos, Quebec. This marks the end of its $75 million expansion program. The mine, probably the world's largest, now produces 600,000 tons per year of fiber, which represents 37% of Canada's output and 13% of world chrysotile production.

2. United Asbestos, Inc., the name of the company resulting from the merger of United Asbestos Corp., Ltd., and Allied Mining Corp., reported that its property in Midlothian Township, Ontario, contains 31 million tons of 9% fiber ore in grades 5, 6, and 7. Production of 100,000 tons per year of fiber is planned to start in 1974 after a very successful test marketing effort.

3. Abitibi Asbestos Mining Co., Ltd., reported proven ore reserves of 100 million tons of ore averaging 4% fiber at its property 50 miles north of Amos, Quebec. Bulk tests have been run through its pilot plant, and fibers are being amassed for test marketing.

4. Rio Tinto Canadian Exploration, Ltd., was evaluating the McAdam Mining Corp., Ltd., property under its option. The property, 20 miles east of Chibougamau, Quebue, has a "C" zone containing 105 million tons of ore grading 3.92% fiber and three other zones containing 86.4 million tons of 3.55% ore.

5. Lake Asbestos of Quebec, Ltd., a subsidiary of American Smelting and Refining Co., has purchased the assets of National Gypsum Co.'s Canadian subsidiary National Asbestos Mines, Ltd., at Thetford Mines. The combined production will put Lake Asbestos at nearly 200,000 tons per year of fiber.

Colombia.—Asbestos Colombianas, S.A. and Nicolet Industries, Inc. is raising its sights from 25,000 tons per year to 60,000 tons per year of fiber from its find in the Department of Antioquia. Reserves are estimated at 18.2 million tons of 4.3% fiber content.

Greece.—The emergence of a healthy and growing asbestos cement products industry has stabilized the "on again, off again" picture of the Kozani deposit. The Asbestos Mines of Northern Greece Mining, S.A. (MABEM), which is 90% owned by Cerro Corp., has finished exploration and pilot plant studies. A plant with 50,000 tons per year (expandable to 1,000,000) will be started in 1974 to process the 50 million tons of ore containing 3% chrysotile of grades 4, 5, and 6.

New Zealand.—Cassiar Asbestos Corp., Ltd., was selected by Kennecott Copper Corp. and Lime and Marble Corp. as a partner to explore and, if warranted, develop the Pyke asbestos find. Exploration and bulk sampling were underway.

Philippines.—La Suerta Resources and Industries, Inc., was actively developing an asbestos prospect in Zambales and negotiating for a Japanese market.

Spain.—Active prospecting for asbestos was underway in the Sierra Nevada where short fibers were once produced.

Swaziland.—The Havelock mine, now owned by Havelock Asbestos Mines, Ltd., in which the Swaziland Government owns a 40% share, with Turner & Newall owning the rest, was having difficulties with weak rock underground. Yield and profits have been suffering.

U.S.S.R.—Comecon members are to construct an asbestos mining and concentration plant at Kiembay in Kazakhstan, according to "Novosti." The 500,000 tons per year of asbestos will be proportioned to members based on their contribution to construction costs. Ore reserves are a reported 24 million tons.

Table 11.—Asbestos: World production by country

(Short tons)

Country [1]	1971	1972	1973 [p]
North America:			
Canada (sales)	1,634,579	1,687,051	1,974,000
Mexico	--	--	17
United States (sold or used by producers)	130,882	131,663	150,036
South America:			
Argentina	433	1,001	[e] 1,100
Brazil [e]	22,000	36,000	44,000
Europe:			
Bulgaria	[e] 3,300	1,653	[e] 3,300
Finland [2]	11,420	7,042	[e] 12,000
France	783	[r e] 780	[e] 780
Italy	131,801	145,675	164,525
Portugal	140	[3] 9	[e] 140
U.S.S.R. [e]	1,270,000	1,345,000	1,411,000
Yugoslavia	17,011	12,170	10,352
Africa:			
Egypt, Arab Republic of	77	486	486
Mozambique	1,577	589	624
Rhodesia, Southern [e]	88,000	88,000	88,000
South Africa, Republic of	355,228	356,206	368,435
Swaziland	39,114	36,817	40,675
Asia:			
China, People's Republic of [e]	175,000	220,000	230,000
Cyprus	30,531	[4] 30,851	29,059
India	12,122	13,528	12,456
Japan	19,762	15,903	15,281
Korea, Republic of (South)	--	2,155	6,268
Taiwan	2,565	2,962	[e] 3,200
Turkey	4,291	5,428	5,201
Oceania:			
Australia	[r] 833	19,015	[e] 35,000
Total	[r] 3,951,449	4,159,984	4,605,935

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition to the countries listed, Czechoslovakia, North Korea and Romania also produce asbestos, but available information is inadequate to make reliable estimates of output levels.

[2] Includes asbestos flour.

[3] Gross weight.

[4] Exports only.

Barite

By Frank B. Fulkerson [1]

Barite producers in the United States sold or used over 1.1 million tons of primary barite in 1973, the highest since 1957. Compared with 1972 figures, quantity and value advanced 22% and 12%, respectively. The tonnage produced in Nevada increased 73%. Imports of crude ore were the highest since 1962. Sales of ground and crushed barite produced from domestic and imported material rose 8% in quantity and 19% in value. Barite mining and processing companies were increasing capacity, to meet growing demand for drilling-mud minerals.

Table 1.—Salient barite and barium-chemical statistics

(Thousand short tons and thousand dollars)

	1969	1970	1971	1972	1973
United States:					
Barite (Primary):					
Sold or used by producers	1,077	854	825	906	1,104
Value	15,753	12,800	13,491	14,883	16,688
Imports for consumption	614	706	484	624	716
Value	5,549	6,314	4,468	5,648	7,596
Ground and crushed sold by producers	1,537	1,388	1,330	1,461	1,571
Value	37,297	34,294	34,020	45,590	54,473
Barium chemicals sold by producers	130	105	83	66	62
Value	19,101	16,961	15,488	13,869	13,899
World: Production	4,238	4,338	4,114	4,362	4,761

Table 2.—Barite (primary) sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1972		1973	
	Quantity	Value	Quantity	Value
Alaska	W	W	W	W
Arkansas	W	W	W	W
California	4	34	11	152
Georgia	W	W	W	W
Missouri	213	3,637	196	3,395
Nevada	317	2,659	549	4,691
Tennessee	W	W	W	W
Undistributed	372	8,553	349	8,450
Total [1]	906	14,883	1,104	16,688

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Data may not add to totals shown because of independent rounding.

DOMESTIC PRODUCTION

Domestic producers reported that 1,104,000 short tons of primary barite was sold or used in 1973. The term "primary barite," as used in this chapter, applies to the first marketable product and includes crude barite, flotation concentrate, and other beneficiated material such as washer, jig, or magnetic separation concentrates.

[1] Industry economist, Division of Nonmetallic Minerals—Mineral Supply.

Barite was produced at 38 mines in 7 States in 1973 (30 mines in 1972). Nevada supplied 50% of the tonnage but only 28% of the value. Barite produced in Nevada had relatively low value, owing to transportation costs and distance to markets. Missouri ranked second in barite production.

Principal producers were Baroid Div., NL Industries, Inc., with mines in Arkansas, Missouri, Nevada, and Tennessee; Dresser Minerals Div., Dresser Industries, Inc., with mines in Arkansas, Missouri, and Nevada; Milchem, Inc., with mines in Missouri and Nevada; IMCO Services, Halliburton Co., with a mine in Nevada; and Alaska Barite Co., Inlet Oil Corp., with a mine in Alaska.

Ground and crushed barite was produced mainly in Louisiana and Texas from imported material, and in Arkansas, Missouri, and Nevada from domestic barite. Processing mills were also located in California, Georgia, Illinois, Tennessee, and Utah.

Among the developments in 1973, Milchem, Inc., began construction near Battle Mountain, Nev., of its second beneficiation plant and its first Nevada grinding mill. Dresser Minerals completed a new beneficiation plant at its Greystone, Nev., mine and announced it would double its production capacity in Missouri by constructing two washing plants.

The remote East Northumberland District in the Toquima Range, Nye County, Nev., recorded its first significant barite production when IMCO Services began a mining operation in the district. Mine run ore was hauled by truck 150 miles to Mina in Mineral County for stockpiling and shipment to the company grinding plant at Houston, Tex. Other new producers in Nevada included Eisenman Chemical Co. and Rocky Mountain Refractories, both in Elko County, and the Milwhite Co. in Elko and Lander Counties.

Molybdenum Corp. of America included a circuit to recover up to 60 tons per day of byproduct barite in its new mill at the Mountain Pass rare earth mine, San Bernardino County, Calif. The large rare earth carbonate ore body contains about 20% barite.[2]

The Minerva Co. commenced production of flotation barite concentrate from the zinc-fluorspar flotation tailing circuit at its Mine No. 1 mill near Cave in Rock, Ill.

Dresser Minerals ceased production at its Magnet Cove, Ark., mine and at the Malvern mill, 12 miles away. Officials said to continue producing would have required a capital expenditure of more than $2 million, because it would be necessary to go to a lower level in the mining operation and construct a new mill nearer the mine. The mine was opened in 1940 by Magnet Cove Barium Corp., which was acquired by Dresser Industries, Inc., in 1949.

CONSUMPTION AND USES

More than 83% of the ground and crushed barite sold in 1973 was used as a weighting agent in oil- and gas-well drilling muds. This use increased 143,100 tons (12%), owing to greater drilling activity. Barite usage as a filler in paint and for barium-chemical manufacturing advanced 6,100 tons (13%) and 3,100 tons (3%), respectively. All other uses declined 37,500 tons (26%). These other uses included filler in rubber, plastics, and paper; flux, oxidizer, and decolorizer in glass manufacturing; and miscellaneous, including ballast for ships, heavy aggregate for concrete, applications in foundries, and unspecified.

Principal consumers of barite to produce barium chemicals were Chemical Products Corp., Cartersville, Ga.; the Great Western Sugar Co., Johnstown, Colo.; Inorganic Chemicals Div., FMC Corp., Modesto, Calif.; Mallinckrodt Chemical Works, St. Louis, Mo.; and Sherwin Williams Chemicals, Coffeyville, Kans. The Great Western Sugar Co. produced barium hydroxide, which it used in sugar beet refining. The other companies sold their production of barium chemicals. Demand exceeded supply, as the result of barium-chemical plant closures in 1971 and 1972.

[2] California Geology. V. 26, No. 12, December 1973, pp. 300–301.

Table 3.—Ground and crushed barite sold, by use [1]

Use [2]	1971 Quantity (short tons)	1971 Percent of total	1972 Quantity (short tons)	1972 Percent of total	1973 Quantity (short tons)	1973 Percent of total
Barium chemicals [3]	140,843	10	105,589	7	108,693	7
Glass	(4)	--	(4)	--	(4)	--
Filler or extender:						
Paint	43,439	3	46,342	3	52,404	3
Rubber	(4)	--	(4)	--	(4)	--
Other filler	22,430	2	(4)	--	(4)	--
Well drilling	1,044,367	77	1,183,340	80	1,326,451	83
Other uses	104,318	8	142,183	10	104,722	7
Total	1,355,397	100	1,477,454	100	1,592,270	100

1 Includes imported barite.
2 Uses reported by producers of ground and crushed barite, except for barium chemicals.
3 Quantities reported by consumers.
4 Included with "Other uses" to avoid disclosing individual company confidential data.

Table 4.—Barium chemicals produced and sold by producers in the United States in 1973 [1]

(Short tons)

Chemical	Plants	Produced	Sold by producers Quantity	Sold by producers Value
Barium carbonate	5	44,898	32,366	$5,279,897
Barium chloride	3	W	W	W
Barium hydroxide	4	W	W	W
Barium oxide	1	W	W	W
Black ash	1	W	W	W
Blanc fixe	2	W	W	W
Other barium chemicals	1	34,877	29,183	8,619,363
Total [2]	6	79,775	61,549	13,899,260

W Withheld to avoid disclosing individual company confidential data; included with "Other barium chemicals."
1 Only data reported by barium-chemical plants that consume barite are included.
2 A plant producing more than one product is counted only once in arriving at total.

PRICES

Price quotations reported in Engineering & Mining Journal were higher in December 1973 than in December 1972. These quotations serve as a general guide and do not necessarily reflect actual transactions. Barite prices are negotiated between buyer and seller.

The average value per ton excluding container cost of crushed and ground barite f.o.b. plant increased from $31.20 in 1972 to $34.67 in 1973. These values were calculated from producers' statements.

Table 5.—Barite price quotations

Item	Price per short ton December 1972	Price per short ton December 1973
Chemical, filler, and glass grades, f.o.b. shipping point, carload lots:		
Hand picked, 95% $BaSO_4$, not over 1% iron	$22.50–$24.50	$29.50–$31.80
Magnetic or flotation, 96% $BaSO_4$, not over 0.5% iron	26.50– 28.50	34.50
Water ground, 99.5% $BaSO_4$, 325 mesh, 50-lb bags	55.00– 78.00	60.00– 80.00
Drilling-mud grade:		
Ground, 83%–93% $BaSO_4$, 3%–12% iron, specific gravity 4.20–4.30, f.o.b. shipping point, carload lots	37.00– 44.00	40.00– 47.00
Crude, imported, specific gravity 4.20–4.30, c.i.f. gulf ports	14.00– 18.00	17.00– 21.00

Source: Engineering and Mining Journal. V. 173, No. 12, December 1972; v. 174, No. 12, December 1973.

FOREIGN TRADE

Imports of crude barite totaled 716,000 tons, an increase of 15% over those of 1972 and the highest since 1962. Average values per ton of crude barite at foreign ports were as follows for the indicated countries: Ireland, $11.12; Mexico, $11.11; and Peru, $7.43. Barite, nearly all of drilling-mud grade, entered the United States through the following customs districts: New Orleans, La., 48%; Laredo, Tex., 23%; Port Arthur, Tex., 21%; and El Paso, Houston, and Galveston, Tex., 8%. Foreign trade statistics also showed imports of crushed or ground witherite (natural barium carbonate), mostly from the United Kingdom, totaling 4,500 tons.

Barium chemical imports, mainly from West Germany and the United Kingdom, increased as the result of a drop in U.S. production of these chemicals.

U.S. barite exports increased 29%. Most of the exports went to Canada and Singapore and were handled through the following customs districts: New Orleans, 50%; Seattle, 22%; Detroit, 19%; other, 9%. The United States exported mostly ground barite and imported mostly crude barite.

Table 6.—U.S. exports of natural barium sulfate and carbonate

Country	1972		1973	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Argentina	--	--	59	$2
Barbados	--	--	283	26
Brazil	165	$6	400	14
Canada	35,158	1,383	38,800	1,579
Colombia	--	--	230	10
Costa Rica	--	--	43	2
Dahomey	r 535	r 42	--	--
Ecuador	122	23	--	--
El Salvador	80	4	47	5
Ethiopia	--	--	2,174	93
France	--	--	196	7
Guatemala	620	r 32	269	11
Honduras	100	5	75	4
Indonesia	--	--	38	1
Israel	--	--	18	1
Jamaica	50	3	--	--
Japan	38	1	71	3
Korea, Republic of	1,599	58	--	--
Leeward and Windward Islands	--	--	26	1
Malaysia	26	1	--	--
Mexico	69	5	378	17
Netherlands	--	--	235	8
New Guinea	--	--	1,878	95
Peru	--	--	20	1
Philippines	24	1	363	17
Saudi Arabia	--	--	1,145	68
Senegal	--	--	648	27
Singapore	13,622	317	19,442	835
South Africa, Republic of	128	6	317	13
Taiwan	--	--	525	28
United Arab Emirates	--	--	178	8
Venezuela	578	22	228	8
Total	r 52,914	r 1,909	68,086	2,884

r Revised.

Table 7.—U.S. exports of lithopone

Year	Quantity (short tons)	Value (thousands)
1971	545	$425
1972	1,395	458
1973	986	357

Table 8.—U.S. imports for consumption of barite, by country

(Thousand short tons and thousand dollars)

Country	1972 Quantity	1972 Value	1973 Quantity	1973 Value
Crude barite:				
Canada	20	228	50	567
France	(1)	3	--	--
Guatemala	--	--	(1)	2
Greece	67	807	51	691
Ireland	154	1,517	227	2,524
Mexico	140	1,456	142	1,577
Morocco	41	500	42	706
Nicaragua	16	119	--	--
Peru	186	1,018	201	1,493
Turkey	--	--	3	36
Total	624	5,648	716	7,596
Ground barite:				
Canada	(1)	3	(1)	16
France	(1)	4	--	--
Mexico	--	--	9	155
United Kingdom	(1)	3	--	--
Total	(1)	10	9	171

[1] Less than ½ unit.

Table 9.—U.S. imports for consumption of barium chemicals

Year	Lithopone		Blanc fixe (precipitated barium sulfate)		Barium chloride		Barium hydroxide	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1971	81	$13	3,522	$576	1,446	$167	--	--
1972	84	17	6,412	1,691	7,316	938	63	$12
1973	84	29	7,522	1,631	10,774	1,987	2,481	800

Year	Barium nitrate		Barium carbonate precipitated		Other barium compounds	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1971	832	$139	1,120	$91	799	$313
1972	685	126	8,316	841	716	334
1973	691	138	10,206	1,603	1,022	531

Table 10.—U.S. imports for consumption of crude, underground, and crushed or ground witherite

Year	Crude, unground		Crushed or ground	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1971	417	$22	94	$20
1972	--	--	1,311	169
1973	141	19	4,470	697

WORLD REVIEW

A two-part article in Industrial Minerals discussed the effect on the world barite industry of increased oil- and gas-well drilling due to the energy shortage. The first part dealt with the North European shelf, and the second part analyzed conditions in Australia, the Far East, and other areas.[3]

Australia.—Dresser Australia Pty., Ltd., planned to place a new barite mine in operation by mid 1975 near Port Hedland in Western Australia.

Canada.—In view of growing demand in foreign markets for drilling-mud grade barite, American Smelting & Refining Co. studied the feasibility of recovering barite from old tailings at its Buchans, Newfoundland, lead-zinc-copper mine. The ore mined at Buchans contains barite as a gangue mineral.[4] Scientists of the National Research Council of Canada recovered grades as high as 97% barite from the old

[3] Bligh, R. P. Barytes in Petroleum Expansion. Ind. Miner. (London), No. 71, August 1973, pp. 9–23; and No. 72, September 1973, pp. 9–23.
[4] Industrial Minerals (London). ASARCO and Barytes for North Sea. No. 73, October 1973, pp. 46–49.

Table 11.—Barite: World production, by country
(Short tons)

Country [1]	1971	1972	1973 p
North America:			
Canada	120,765	77,261	98,000
Mexico	308,362	288,147	281,372
United States [2]	825,000	906,000	1,104,000
South America:			
Argentina	r 23,435	25,645	e 27,500
Brazil e	47,100	51,000	79,700
Chile	1,413	2,864	6,506
Colombia	6,382	e 7,000	2,119
Peru	113,004	e r 226,000	e 237,000
Europe:			
Austria	870	223	472
Czechoslovakia e	8,300	8,300	8,300
France	121,254	e 110,000	e 121,000
Germany, East e	33,000	33,000	33,000
Germany, West	450,693	406,434	359,910
Greece [3]	93,635	110,584	e 121,000
Ireland	216,160	257,356	e 275,500
Italy	222,144	200,365	e 183,500
Poland e	61,000	55,000	55,000
Portugal	1,268	909	1,135
Romania e	128,000	128,000	128,000
Spain	91,789	145,505	e 165,000
U.S.S.R. e	331,000	342,000	356,000
United Kingdom e	29,000	24,000	25,000
Yugoslavia	71,308	77,744	e 83,000
Africa:			
Algeria [4]	40,234	38,764	e 38,500
Egypt, Arab Republic of	321	1,878	e 2,200
Kenya	819	692	e 900
Morocco	93,117	102,779	113,197
South Africa, Republic of	3,265	2,775	e 3,300
Swaziland	159	136	128
Tunisia	1,965	1,310	20,465
Asia:			
Burma	25,312	28,627	17,472
China, People's Republic of e	154,000	171,000	182,000
India	64,700	50,831	128,529
Iran [5]	66,000	88,185	110,000
Japan	63,096	66,659	72,000
Korea, North e	132,000	132,000	132,000
Korea, Republic of	23	33	225
Pakistan	3,265	2,648	1,872
Philippines	--	--	3,595
Thailand	70,040	107,024	55,000
Turkey	31,468	53,923	98,703
Oceania: Australia	r 59,316	28,977	e 28,600
Total	r 4,113,982	4,361,578	4,760,700

e Estimated. p Preliminary. r Revised.
[1] In addition to the countries listed, Bulgaria and Southern Rhodesia also produce barite, but available information is inadequate to make reliable estimates of production.
[2] Sold or used by producers.
[3] Barite concentrates.
[4] Ground barite.
[5] Year beginning March 21 of that stated.

tailings in laboratory tests using a two stage agglomeration process.[5]

Dresser Minerals planned to open a new mine in northern British Columbia to serve the drilling mud market in western and northern Canada.

France.—A research group formed in 1968 by the Bureau de Recherches Géologiques et Minières, and Mines de Garrot S.A. completed a study of methods to treat ore from the large Chaillac deposit, situated 30 miles southwest of Châteauroux, in the Indre area. Exploitation of the deposit has been prohibited by the nature of the ore, which is a very fine barite-iron oxides composite. Flotation was the beneficiation process finally chosen. It was estimated that the recovery of barite would be about 85%. The content of concentrates would be about 97% $BaSO_4$.

India.—High-grade lump barite was being exported from a new mine 120 miles from Madras. Shipments included a 15,000-ton cargo to Poland and smaller lots to Norway and elsewhere. Production at the mine was running at 500 tons per day and was entirely by hand labor using a labor force of over 400.[6]

Ireland.—Milchem, Ltd., began production in September at its 60,000-ton-per-year barite flotation plant in County Galway. The plant treats the Irish Base Metals, Ltd., tailings pond. Both Milchem and IMCO Services conducted barite exploration programs in Ireland in 1973.

Thailand.—Most of the barite produced in Thailand was shipped to grinding mills in Singapore. Several barite prospects were investigated during the year. Jalupathan Cement Co. installed grinding equipment for production of drilling mud grade barite.

United Kingdom.—Aberdeen Barytes Co., Ltd., installed a grinding mill at Aberdeen, Scotland. Anchor Drilling Fluids Division, Maritime Drilling Services, Ltd., planned to construct a new grinding mill at Dundee, Scotland.

TECHNOLOGY

The Calico mining district about 10 miles east of Barstow, Calif., contains extensive deposits of low-grade silver-barite ore. Laboratory beneficiation work was done by Bureau of Mines scientists on four ore samples from the district to develop methods to recover the values. The samples assayed at 2 to 3 ounces of silver per ton and 7% to 12% barite. Cyanidation recovered from 47% to 60% of the silver. From 75% to 90% of the barite was recovered in a plus 92% barite product from cyanidation residues. Salt roasting the ore samples before cyanidation increased silver recoveries, but a high-grade barite product could not be floated from the residues.[7]

Sachtleben Chemie Gmbh of Cologne, West Germany, developed a new weighting agent for oil and gas well-drilling muds. The material, known as Fer-O-Bar, was prepared from iron oxide cinders resulting from the calcination of pyrite ores. Laboratory tests showed that the Fer-O-Bar might be a satisfactory substitute for barite.[8]

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[5] Meadus, F. W., and I. E. Puddington. The Beneficiation of Barite by Agglomeration. Can. Min. and Met. Bull., v. 66, No. 734, June 1973, pp. 123–126.
Meadus, F. W., and I. E. Puddington. (assigned to National Research Council). Economic Recovery of Barite From Relatively Low-grade Ores, Mill Tailings, or the Like. Can. Pat. 939,837, Jan. 8, 1974.

[6] Industrial Minerals (London). No. 69, June 1973, p. 53.

[7] Agey, W. W., J. V. Batty, H. W. Wilson, and W. J. Wilson. Beneficiation of Calico District, California, Silver-Barite Ores. BuMines RI 7730, 1973, 15 pp.

[8] Industrial Minerals. Sachtleben's Fer-O-Bar. No. 68, May 1973, pp. 33–34.

Bauxite

By Horace F. Kurtz [1]

World bauxite production totaled about 70 million long tons in 1973, compared with 30 million tons 10 years earlier. The strong growth in world bauxite production, 9% in 1973, largely reflected a continued rising demand for aluminum, the principal end use of bauxite. World alumina production, the intermediate step between bauxite and aluminum production, increased 11% to nearly 29 million short tons.

U.S. production and imports of bauxite in 1973 remained near the 1972 levels. A reduction in bauxite inventories enabled domestic alumina production to be increased. This increase, together with sharply higher imports of alumina, was sufficient to meet the demand for making aluminum.

Legislation and Government Programs.—Jamaica-type metallurgical-grade bauxite in government stockpiles was authorized for sale during 1973, but none was sold. Surinam-type bauxite sold previously was shipped from government stockpiles.

The Environmental Protection Agency issued proposed plant effluent limitations which included restrictions on the discharge of waste water from alumina plants into navigable waters.[2]

Table 1.—Salient bauxite statistics

(Thousand long tons and thousand dollars)

	1969	1970	1971	1972	1973
United States:					
Production, crude ore (dry equivalent)	1,843	2,082	1,988	1,812	1,879
Value	25,725	30,070	28,543	23,238	26,635
Exports (as shipped)	5	3	34	29	12
Imports for consumption [1]	12,160	12,620	12,326	11,428	11,240
Consumption (dry equivalent)	15,580	15,673	15,619	15,375	16,642
World: Production	51,008	56,873	r 61,143	r 64,021	68,563

r Revised.

1 Import figures for Jamaica, Haiti, and the Dominican Republic were adjusted by the Bureau of Mines to dry equivalent. Other bauxite imports, which are virtually all dried, are on an as-shipped basis. Excludes calcined bauxite and bauxite imported into the Virgin Islands.

DOMESTIC PRODUCTION

Bauxite production in the United States increased 4% to 1.88 million long tons (dry equivalent) in 1973. About 90% of the bauxite was produced in Arkansas. The remainder was mined in Alabama and Georgia. Except for the Mars Hill underground mine of Reynolds Mining Corp. in Saline County, Ark., all of the bauxite mines were open pit operations.

In Arkansas, Aluminum Co. of America (Alcoa), American Cyanamid Co., and Reynolds produced in Saline County, and Stauffer Chemical Co. mined in Pulaski County. Bauxite-processing plants were operated by American Cyanamid, Porocel Corp., and Stauffer.

Bauxite was mined in Alabama in Barbour County by Eufaula Bauxite Mining Co., A. P. Green Refractories Co., and Wilson-Snead Mining Co., and in Henry County by Abbeville Lime Co., Harbison-Walker Refractories Co., and Wilson-Snead. Drying or calcining facilities were operated by A. P. Green, Harbison-Walker, and Wilson-Snead.

American Cyanamid and C-E Minerals, a division of Combustion Engineering, Inc.,

[1] Industry economist, Division of Nonferrous Metals—Mineral Supply.

[2] Environmental Protection Agency. Nonferrous Metals Manufacturing Point Source Category. Federal Register, v. 38, No. 230, Nov. 30, 1973, pp. 33169–33183.

mixed bauxite in Sumter County, Georgia. Treatment plants were located at Andersonville, Ga.

The eight alumina plants in the continental United States and the one plant in the U.S. Virgin Islands produced a total

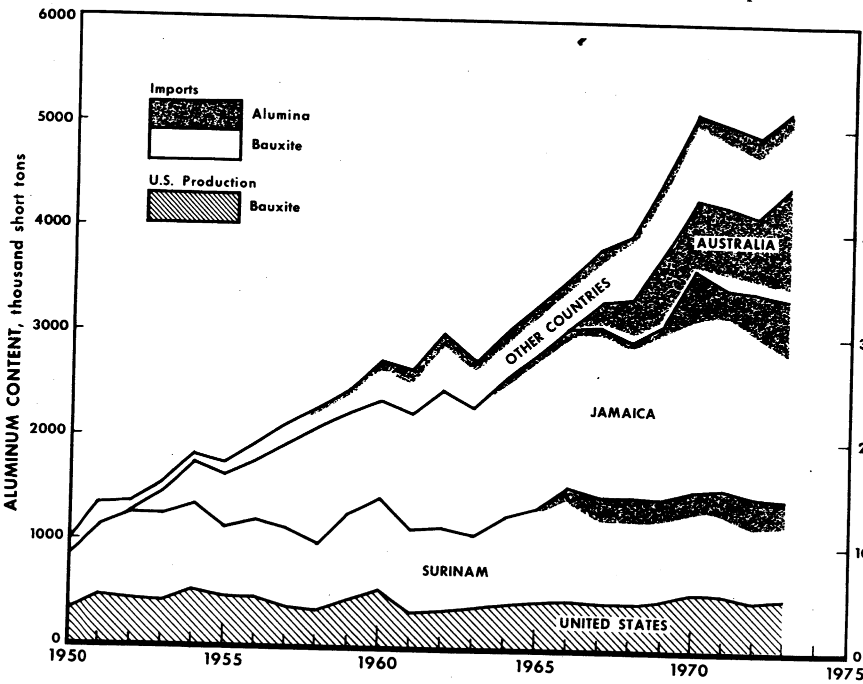

Figure 1.—Estimated new supply of bauxite and alumina in the United States and Virgin Islands.

Table. 2.—Mine production of bauxite and shipments from mines and processing plants to consumers in the United States

(Thousand long tons and thousand dollars)

State and year	Mine production			Shipments from mines and processing plants to consumers		
	Crude	Dry equivalent	Value [1]	As shipped	Dry equivalent	Value [1]
Alabama and Georgia:						
1969	117	88	1,020	72	79	1,324
1970 [2]	270	213	3,778	149	161	3,299
1971	261	207	3,564	143	171	3,566
1972	227	178	2,228	187	218	4,605
1973	247	193	2,751	221	265	5,782
Arkansas:						
1969	2,116	1,755	24,706	2,044	1,765	26,304
1970	2,251	1,869	26,293	2,194	1,917	29,049
1971	2,157	1,781	24,979	2,161	1,892	28,296
1972	1,973	1,634	21,010	2,128	1,844	25,426
1973	2,040	1,686	23,884	2,079	1,782	27,180
Total United States: [3]						
1969	2,233	1,843	25,725	2,116	1,844	27,628
1970 [2]	2,522	2,082	30,070	2,343	2,078	32,348
1971	2,419	1,988	28,543	2,305	2,063	31,862
1972	2,200	1,812	23,238	2,314	2,061	30,032
1973	2,287	1,879	26,635	2,300	2,047	32,962

[1] Computed from selling prices and values assigned by producers and from estimates of the Bureau of Mines.
[2] Includes data from Oregon and Washington.
[3] Data may not add to totals shown because of independent rounding.

Table 3.—Recovery of dried, calcined, and activated bauxite in the United States

(Thousand long tons)

Year	Crude ore treated	Total processed bauxite recovered [1] As recov-ered	Total processed bauxite recovered [1] Dry equiva-lent
1969	288	162	218
1970	428	259	343
1971	444	250	357
1972	399	210	319
1973	338	169	287

[1] Dried, calcined, and activated bauxite.

Table 4.—Percent of domestic bauxite shipments, by silica content

SiO_2 (percent)	1969	1970	1971	1972	1973
Less than 8	15	19	4	6	6
From 8 to 15	55	54	65	64	61
More than 15	30	27	31	30	33

of 7.57 million short tons of alumina and aluminum oxide products in 1973, an increase of 8%. The total production included 6.83 million tons of calcined alumina, 635,000 tons of commercial alumina trihydrate, and 99,000 tons of tabular, activated, and other alumina. Consolidated Aluminum Corp. (Conalco), 60% of which is owned by Swiss Aluminium Ltd. and 40% by Phelps Dodge Corp., acquired half interest in the Burnside, La., alumina plant of Ormet Corp. when it purchased the aluminum operations of Olin Corp. near the end of the year. Revere Copper and Brass, Inc., owned the other half of Ormet.

Domestic alumina shipments totaled 7.56 million tons and were valued at $532 million, compared with $479 million (revised) in 1972. Approximately 6.57 million tons was shipped to primary aluminum plants. The chemical industry, including producers of aluminum fluoride fluxes for aluminum plants, received the second largest tonnage, and most of the remaining alumina was shipped to producers of abrasives, ceramics, and refractories.

Table 5.—Production and shipments of alumina in the United States

(Thousand short tons)

Year	Calcined alumina	Other alumina [1]	Total: As produced or shipped [2]	Total: Calcined equivalent
Production: [3]				
1970	6,670	478	7,148	7,001
1971	6,545	668	7,213	7,002
1972	6,235	741	6,976	6,739
1973	6,834	734	7,568	7,344
Shipments:				
1970	6,631	476	7,106	6,961
1971	6,525	659	7,184	6,975
1972	6,222	745	6,968	6,730
1973	6,822	738	7,561	7,335

[1] Trihydrate, activated, tabular, and other aluminas. Excludes calcium and sodium aluminates.
[2] Data may not add to totals shown because of independent rounding.
[3] Includes only the end product if one type of alumina was produced and used to make another type of alumina.

Table 6.—Capacities of domestic alumina plants, December 31, 1973 [1]

(Thousand short tons per year)

Company and plant	Capacity
Aluminum Co. of America:	
Bauxite, Ark	e 375
Mobile, Ala	e 1,025
Point Comfort, Tex	e 1,350
Total	2,750
Martin Marietta Aluminum, Inc.:	
St. Croix, V.I	360
Kaiser Aluminum & Chemical Corp.:	
Baton Rouge, La	1,025
Gramercy, La	800
Total	1,825
Ormet Corp.: Burnside, La	600
Reynolds Metals Co.:	
Hurricane Creek, Ark	840
Corpus Christi, Tex	1,385
Total	2,225
Grand total	7,760

e Estimate by the Bureau of Mines.
[1] Capacity may vary depending upon the bauxite used.

CONSUMPTION AND USES

Bauxite consumption in the United States (including the Virgin Islands) increased 8% to 16.6 million long tons (dry basis). Most of the increase was consumed in the production of calcined alumina for the aluminum industry, although all major consuming industries increased the use of bauxite. Foreign sources provided about 88% of the total bauxite consumed in 1973.

The production of alumina and related products required 93% of the total bauxite consumed. An average of 2.11 long dry tons of bauxite was used to produce 1 short ton (calcined basis) of alumina. The two alumina plants in Arkansas used mainly bauxite mined in Arkansas, and the other seven alumina plants used only imported ore.

The refractories industry used nearly one-half million tons (dry weight basis) of bauxite, establishing another record high level. Nearly all of this bauxite was used in the calcined form, which weighs about 65% of the dry equivalent weight. Imports, mainly from Guyana, comprised 83% of the bauxite used in refractories.

Five companies consumed bauxite in manufacturing artificial abrasives, and all of the bauxite used was calcined. The bulk of the ore came from Surinam, while most of the remainder came from the People's Republic of China. Data on consumption by the abrasives industry included bauxite fused and crushed in Canada because much of this material is made into abrasive wheels and coated products in the United States. About 10% to 15% of this material is used for nonabrasive applications, principally refractories.

Bauxite consumption by the chemicals

Table 7.—Bauxite consumed in the United States, by industry

(Thousand long tons, dry equivalent)

Year and industry	Domestic	Foreign	Total [1]
1972:			
Alumina	1,733	12,626	14,359
Abrasive [2]	--	253	253
Chemical	[3] 142	[3] 218	284
Refractory	75	329	403
Other	W	W	76
Total [1] [2]	1,950	13,425	15,375
1973:			
Alumina	1,725	13,784	15,509
Abrasive [2]	--	259	259
Chemical	[3] 167	[3] 211	313
Refractory	81	414	496
Other	W	W	65
Total [1] [2]	1,974	14,668	16,642

W Withheld to avoid disclosing individual company confidential data; included with "Chemical."
[1] Data may not add to totals shown because of independent rounding.
[2] Includes consumption by Canadian abrasive industry. Small quantity of domestic bauxite included with foreign in 1973.
[3] Includes other uses.

Table 8.—Crude and processed bauxite consumed in the United States

(Thousand long tons, dry equivalent)

Type	Domestic origin	Foreign origin	Total [1]
1972:			
Crude and dried	1,766	12,838	14,602
Calcined and activated	185	588	772
Total [1]	1,950	13,425	15,375
1973:			
Crude and dried	1,748	13,995	15,743
Calcined and activated	226	673	899
Total	1,974	14,668	16,642

[1] Data may not add to totals shown because of independent rounding.

industry increased 10%. The United States, Guyana, and Surinam were the principal sources of bauxite for this industry. Other consumers of bauxite, in descending order of magnitude, included the cement, oil and gas, and steel and ferroalloys industries, and municipal waterworks.

Thirty-one primary aluminum plants in the United States consumed 8.73 million short tons of calcined alumina, compared with 7.94 million tons in 1972. Alumina consumption data for other uses were not available. A significant quantity was used to make aluminum fluoride and synthetic cryolite, which is also used in the production of primary aluminum.

Table 9.—Production and shipments of selected aluminum salts in the United States in 1972

(Thousand short tons and thousand dollars)

Item	Number of producing plants	Production	Total shipments including interplant transfers: Quantity	Total shipments including interplant transfers: Value
Aluminum sulfate:				
Commercial (17% Al_2O_3)	67	1,256	1,194	$51,648
Municipal (17% Al_2O_3)	3	5	XX	XX
Iron-free (17% Al_2O_3)	17	71	49	3,046
Aluminum chloride:				
Liquid (32°Bé) } Crystal (32°Bé) }	5	NA	NA	NA
Anhydrous (100% $AlCl_3$)	5	NA	NA	NA
Aluminum fluoride, technical	6	33	32	8,864
Aluminum hydroxide, trihydrate (100% $Al_2O_3 \cdot 3H_2O$)	7	529	503	47,175
Other inorganic aluminum compounds [1]	XX	XX	XX	27,258

NA Not available. XX Not applicable.
[1] Includes sodium aluminate, light aluminum hydroxide, cryolite, and alums.

Source: Data are based upon Bureau of the Census report Form MA-28E.1, Annual Report on Shipments and Production of Inorganic Chemicals.

STOCKS

Total stocks of bauxite in the United States were drawn down by 6%, or about 1.2 million long dry tons, during 1973. A reduction in bauxite inventories at alumina plants accounted for about half of the decline. Government stockpiles were reduced 3%. About 314,000 tons of Surinam-type bauxite was shipped from Government defense inventories, and an additional 110,000 tons was withdrawn from a government stockpile accumulated during World War II.

The Government stockpile objectives for Surinam-type bauxite and refractory-grade bauxite were eliminated in 1973, and the stockpile objective for Jamaica-type bauxite was lowered to 4,638,000 tons. At yearend, the Government stockpiles contained an additional 9,789,000 long tons, dry basis, classified as uncommitted excess (unsold) bauxite. The remaining 1,602,000 tons were committed for sale.

Inventories of alumina and related products at plants producing alumina and primary aluminum totaled 1,239,000 short tons on December 31, 1973, an increase of 14% from the 1,083,000 tons (revised) at the end of 1972. The Government held no stocks of alumina except in the form of abrasive grain and crude fused aluminum oxide. These inventories totaled 390,000 short tons.

Table 10.—Stocks of bauxite in the United States [1]

(Thousand long tons, dry equivalent)

Sector	Dec. 31, 1972	Dec. 31, 1973
Producers and processors	r 791	684
Consumers	r 2,797	2,165
Government [2]	16,453	16,029
Total	r 20,041	18,878

r Revised.
[1] Domestic and foreign bauxite: crude, dried, calcined, activated; all grades.
[2] Includes bauxite stockpiled during World War II (781,000 tons Dec. 31, 1972, 671,000 tons Dec. 31, 1973) plus bauxite in defense material inventories (national stockpile, supplemental stockpile, Defense Production Act).

PRICES

Prices on most of the bauxite and alumina produced throughout the world are not quoted because the large tonnages used by the aluminum industry are usually obtained from affiliated companies or purchased under long-term negotiated contracts.

Bureau of Mines estimates of the value of domestic production were based on data supplied by producers. The Bureau's estimated average value of crude domestic bauxite shipments in 1973, f.o.b. mine or plant, was $11.58 per long ton, compared with $10.60 in 1972. The average value of shipments of domestic calcined bauxite was estimated at $41.78 per ton, compared with $31.38 in 1972. Bauxite values among producers varied widely because of differences in grade.

The average value of imported dried or partially dried bauxite consumed at alumina plants in the United States and the Virgin Islands in 1973 was estimated at $14.84 per long dry ton. Engineering and Mining Journal published the following prices on supercalcined refractory-grade bauxite imported from Guyana, car lots, per long ton:

	January–June	July–December
F.o.b. Baltimore, Md	$60.50	$62.50
F.o.b. Mobile, Ala	60.50	62.53

The average value of domestic calcined alumina shipments, as determined from producers' reports, was $66.85 per short ton. Shipments of alumina trihydrate averaged $77.71 per ton. The average value of imported alumina (including small quantities of hydrate) was $62.02 per ton at port of shipment. Exports of alumina from the United States and the Virgin Islands averaged $83.48 per ton.

Table 11.—Market quotations on alumina and aluminum compounds

(In bags, carlots, freight equalized)

Compounds	Jan. 1, 1973	Dec. 31, 1973
Alumina, calcined .... per pound	$0.06	$0.06
Alumina, hydrated, heavy .... do	$0.0445– .0455	$0.0445– .0455
Alumina, activated, granular, works .... do	.1365	.1365
Aluminum sulfate, commercial, ground (17% Al_2O_3) .... per ton	67.25	67.25
Aluminum sulfate, iron-free dry (17% Al_2O_3) .... do	92.05	98.60

Source: Chemical Marketing Reporter.

Table 12.—Average value of U.S. exports and imports of bauxite [1]

(Per long ton)

Type and country	Average value, port of shipment		
	1971	1972	1973
Exports: Bauxite and bauxite concentrate	$45.02	$44.59	$59.35
Imports:			
Crude and dried:			
Australia	10.68	11.24	11.37
Dominican Republic [2]	16.58	17.92	15.48
Greece	8.41	14.33	11.04
Guinea	4.93	5.37	8.53
Guyana	11.20	10.09	9.89
Haiti [2]	9.86	10.79	10.80
Jamaica [2]	12.76	13.48	13.28
Surinam	11.12	11.96	11.61
Average	12.46	13.21	12.72
Calcined:			
Guyana	39.85	50.49	53.93
Surinam	34.87	47.20	51.27
Average	39.33	50.04	53.60

[1] Excludes bauxite into the Virgin Islands from foreign countries: 1971—Australia $5.54, Papau New Guinea $4.31, Guinea $4.94; 1972—Australia $4.74, Guinea $4.82, Guyana $7.01; 1973—Australia $13.66, Guyana $6.98.

[2] Dry equivalent tons adjusted by Bureau of Mines used in computation.

Note: Bauxite is not subject to an ad valorem rate of duty, and the average values may be arbitrary for accountancy between allied firms, etc. Consequently, the data do not necessarily reflect market values in the country of origin.

FOREIGN TRADE

Exports from the United States classified as "bauxite and concentrates of aluminum excluding alumina" totaled only 12,000 long tons in 1973 and were valued at $811,000. Canada received 88% of the total.

Alumina exports, including 26,000 tons of aluminum hydroxide, decreased 13% to 765,000 short tons, the lowest level since 1967. Canada received 43% of the total, Ghana received 17%, and Mexico received 13%. Reduced shipments to the U.S.S.R. accounted for most of the decline in exports from the United States mainland, although the U.S.S.R. and Norway shared an additional 283,000 tons exported from the U.S. Virgin Islands to foreign countries.

Exports of aluminum sulfate increased to 21,000 tons, valued at $642,000. The largest of the 27 recipient countries were Venezuela, which received 15,000 tons, and Canada, which received 2,500 tons. Artificial corundum exports increased to 30,000 tons, valued at $11.5 million, of which 10,000 tons was shipped to Canada, 8,000 tons to the United Kingdom, and 2,000 tons to Sweden. Exports classified as "other aluminum compounds" totaled 42,000 tons and were valued at $14.1 million. Much of this tonnage was believed to be aluminum fluoride and synthetic cryolite shipped to other countries for use as a flux in making primary aluminum.

No duties were imposed on imports of bauxite, alumina, or aluminum hydroxide in 1973. All duties on these commodities were suspended effective July 15, 1971.

Imports of crude, partially dried, and dried bauxite declined 2% to 11.24 million long tons in 1973, the third consecutive year of reduced imports. Decreased imports of bauxite from Jamaica and Haiti more than offset increases from all other countries that regularly supply the United States; however, Jamaica continued to supply over half the total imports. Bauxite imports into the Virgin Islands totaled an additional 625,000 tons, virtually unchanged from the previous year. Imports from Guinea to the United States began on a regular basis in the second half of 1973 and were expected to become an important new source of bauxite.

Calcined bauxite imports, which were used largely in the manufacture of refractories, increased to 294,000 tons. Guyana provided 84% of the total and Surinam most of the remainder. Additional calcined bauxite was imported into Canada for manufacture into crude fused aluminum oxide, much of which was subsequently

Table 13.—U.S. exports of alumina,[1] by country

(Thousand short tons and thousand dollars)

Country	1971		1972		1973	
	Quantity	Value	Quantity	Value	Quantity	Value
Canada	273	21,350	282	21,119	328	25,299
France	1	479	2	475	2	627
Germany, West	23	2,647	2	1,383	11	1,518
Ghana	109	7,207	106	5,652	133	8,749
Hungary	60	3,594	44	2,594	--	--
Japan	2	1,618	3	4,022	6	6,910
Mexico	97	6,528	109	7,572	101	7,442
Poland	19	1,381	43	3,182	20	1,180
Sweden	10	717	19	1,351	66	3,892
U.S.S.R	434	24,751	237	12,835	48	2,800
United Kingdom	2	695	2	623	4	1,878
Venezuela	17	1,417	20	1,577	33	2,633
Yugoslavia	--	--	--	--	3	735
Other	33	5,243	10	3,317	10	3,415
Total	1,080	77,627	879	65,702	765	67,078

[1] Includes exports of aluminum hydroxide: 1971—34,000 short tons; 1972—41,000 short tons; 1973—26,000 short tons.

Note: Excludes alumina exported from the Virgin Islands to foreign countries: 1971—Norway 116,000 tons, U.S.S.R. 65,000 tons; 1972—Cyprus 26,000 tons, Norway 191,000 tons, Poland 58,000 tons; 1973—Norway 157,000 tons, U.S.S.R. 126,000 tons.

Table 14.—U.S. imports for consumption of bauxite (crude and dried), by country[1]

(Thousand long tons and thousand dollars)

Country	1971		1972		1973	
	Quantity	Value	Quantity	Value	Quantity	Value
Australia	139	1,485	277	3,116	359	4,082
Dominican Republic	912	15,119	851	15,258	916	14,181
Greece	34	286	3	43	45	491
Guinea	15	74	8	43	128	1,095
Guyana	271	3,034	360	3,635	483	4,778
Haiti	502	4,951	422	4,556	307	3,314
Jamaica	7,583	96,767	6,958	93,860	6,345	84,267
Sierra Leone	--	--	15	172	--	--
Surinam	2,870	31,923	2,534	30,327	2,651	30,792
Venezuela	--	--	--	--	6	75
Other	--	--	(2)	2	--	--
Total	12,326	153,639	11,428	151,012	11,240	143,075

[1] Official Bureau of the Census data for Jamaican, Haitian, and Dominican Republic bauxite have been converted to dry equivalent by deducting free moisture: Jamaican is 15.4%, Haitian 13%, and Dominican Republic 16.8%. Other imports, which are virtually all dried, are on as-shipped basis.

[2] Less than ½ unit.

Note: Excluded bauxite imported into the Virgin Islands from foreign countries: 1971—Australia 393,000 tons, Papua-New Guinea 30,000 tons, Guinea 588,000 tons; 1972—Australia 220,000 tons, Guinea 57,000 tons, Guyana 347,000 tons; 1973—Australia 161,724 tons, Guyana 463,470 tons.

Table 15.—U.S. imports for consumption of bauxite (calcined), by country

(Thousand long tons and thousand dollars)

Country	1971		1972		1973	
	Quantity	Value	Quantity	Value	Quantity	Value
Australia	--	--	6	223	--	--
Canada	(1)	1	(1)	6	6	397
Guyana	247	9,857	185	9,342	247	13,300
Surinam	30	1,040	35	1,652	36	1,843
Trinidad and Tobago	15	579	21	1,139	--	--
Zaire	--	--	--	--	5	210
Other	(1)	10	--	--	(1)	1
Total	292	11,487	247	12,362	294	15,751

[1] Less than ½ unit.

Table 16.—U.S. imports for consumption of alumina,[1] by country

(Thousand short tons and thousand dollars)

Country	1971 Quantity	1971 Value	1972 Quantity	1972 Value	1973 Quantity	1973 Value
Australia	1,240	66,634	1,168	67,674	1,939	116,571
Canada	17	1,883	20	2,136	21	2,489
France	84	5,135	23	1,936	1	924
Germany, West	3	755	1	433	3	1,075
Greece	63	3,951	107	6,138	--	--
Guinea	(2)	30	5	357	21	1,294
Guyana	13	929	58	3,534	33	1,936
Jamaica	458	30,681	748	48,836	904	57,768
Japan	68	4,968	138	8,599	73	5,077
Surinam	463	26,851	571	32,916	380	22,008
Other	1	87	11	854	(2)	187
Total	2,410	141,904	2,850	173,413	3,375	209,329

[1] Includes small quantities of aluminum hydroxide.
[2] Less than ½ unit.

Note: Shipments from the Virgin Islands to the United States: 1971—120,000 short tons ($9,316,-000); 1972—67,051 short tons ($4,827,674); 1973—23,424 short tons ($1,686,505).

used in abrasive and refractory products in the United States. An estimated 80% of these Canadian imports came from Surinam, and most of the remainder came from the People's Republic of China.

Imports of alumina, including small quantities of aluminum hydroxide, increased 18% to a record high level of 3.4 million short tons. Receipts from Australia increased by 771,000 tons. Of the total alumina imports, Australia provided 57%, Jamaica 27%, and Surinam 11%.

WORLD REVIEW

World bauxite production was estimated at nearly 70 million long dry tons in 1973, an increase of 9%. The greatest production increases occurred in Australia, Jamaica, and Guinea, while India showed the largest decline. Australia and Jamaica together produced 44% of the world's supply.

World production of alumina increased 11%. The United States, with 26% of the total, remained the largest producer, but Australian output showed the greatest growth, increasing by over 1 million short tons.

Australia.—Australia was the world's largest producer of bauxite and the second largest producer of alumina. In Western Australia, Alcoa of Australia (W.A.) Ltd. operated alumina plants at Kwinana and Pinjarra using bauxite mined in the Darling Range. Alumina from both plants was shipped from Kwinana, but port facilities at Bunbury were being prepared to handle future shipments from Pinjarra. The Pinjarra plant was reported to be undergoing an expansion to a capacity of about 1 million tons per year, which should be completed in 1975. Additional expansion was being considered.

Comalco Ltd. conducted the world's largest bauxite mining operation at Wiepa, Queensland, on the Cape York Peninsula. The deposits and the operations were described.[3] Shipments of beneficiated bauxite from Wiepa increased by 2 million tons in 1973 to 9.1 million tons. Of the total, 4.3 million tons went to the Gladstone and Bell Bay alumina plants in Australia, 1.7 million tons to Japan, and 3.1 million tons to Europe and other areas. Sales of calcined abrasive-grade bauxite also increased. A second calcining kiln, with a capacity of 150,000 tons and costing $4.5 million, was expected to be completed by the end of 1974.

Queensland Alumina Ltd. completed the third expansion of its Gladstone alumina plant. Annual rated capacity was raised to 2.2 million short tons, and production in 1973 was about 2 million tons. Comalco shut down its 20-year-old alumina plant at Bell Bay, Tasmania, for economic reasons after operating it through most of 1973. After 4 years of study, a group of companies led by Comalco decided that it would be uneconomic to construct a large alumina plant in the Wiepa area in the near future.

[3] Mining Magazine. Weipa Bauxite. V. 130, No. 1, January 1974, pp. 12–21.

Table 17.—Bauxite: World production, by country

(Thousand long tons)

Country [1]	1971	1972	1973 [p]
North America:			
Dominican Republic [2] [3]	[r] 1,071	1,019	1,127
Haiti [4]	633	677	[e] 690
Jamaica [5]	12,244	12,345	13,385
United States [2]	1,988	1,812	1,879
South America:			
Brazil	530	596	[e] 640
Guyana [2]	[r] 3,858	3,291	3,224
Surinam	6,612	7,654	6,580
Europe:			
France	3,134	3,203	3,084
Germany, West	3	2	--
Greece	2,816	2,398	[e] 2,600
Hungary	2,057	2,321	2,559
Italy	191	95	49
Romania [e]	300	300	340
Spain	5	6	7
U.S.S.R. [e] [6]	[r] 4,000	[r] 4,100	4,200
Yugoslavia	1,928	2,162	2,133
Africa:			
Ghana	[r] 323	356	305
Guinea	[r] 1,966	2,018	[e] 3,000
Mozambique	7	5	6
Sierra Leone	581	683	652
Asia:			
China, People's Republic of [e] [7]	540	570	590
India	1,493	1,628	1,250
Indonesia	1,218	1,256	1,200
Malaysia (West Malaysia)	962	1,059	[e] 1,200
Pakistan	(8)	1	(8)
Turkey	151	255	328
Oceania: Australia	[r] 12,532	14,209	17,535
Total	[r] 61,143	64,021	68,563

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition to the countries listed, Southern Rhodesia may have continued to produce bauxite during the period covered by this table. However, no information on bauxite-mining activities, if any, has been available since 1965.

[2] Dry bauxite equivalent of crude ore.

[3] Shipments.

[4] Dry bauxite equivalent of ore processed by drying plant.

[5] Bauxite processed for conversion to alumina in Jamaica plus exports of kiln-dried ore.

[6] Excludes materials other than bauxite used for the production of alumina, estimated as follows in thousand long tons: Nepheline concentrates (25% to 30% alumina), 1971—[r] 1,102, 1972—[r] 1,673, 1973—2,116, alunite ore (16% to 18% alumina), 1971—[r] 394, 1972—[r] 492, 1973—590.

[7] Diasporic bauxite for production of aluminum only; excludes 98,000 to 195,000 tons of production for refractory applications.

[8] Less than ½ unit.

Nabalco Pty., Ltd., produced bauxite and alumina at Gove, Northern Territory. The second stage of the Gove alumina plant was put into operation in the middle of the year increasing annual capacity to 1.1 million tons.

The Alwest bauxite and alumina project in southern Western Australia was reported to have been delayed because of financing difficulties. Federal rules requiring Australian majority equity and no-interest bank deposits of one-third of all foreign investments were cited as major deterrents to foreign participation.

Brazil.—Bauxite mining has historically been centered in Minas Gerais, and none has been mined commercially in northern Brazil. However, deposits discovered in the Amazon Area since 1967 may eventually prove large enough to give Brazil the greatest bauxite production potential in the Western Hemisphere. Government regulations and procedures relating to the development of mineral deposits were described.[4]

During 1973 Alcan Aluminum Ltd. and Companhia Vale do Rio Doce (CVRD) conducted a joint study of the possibility of developing the bauxite deposits Alcan discovered near the confluence of the Amazon and Trombetas Rivers. In December the companies announced the signing of a memorandum of understanding with eight other companies to underwrite further development of the project. Tentative plans called for construction to begin in mid-

[4] Lefond, S. J. Brazilian Mining: Relaxed Government Attitudes Pave the Way for Exploiting Critical Reserves. Min. Eng., v. 25, No. 11, November 1973, pp. 31-45.

Table 18.—Alumina: World production, by country

(Thousand short tons)

Country [1]	1971	1972	1973 [p]
North America:			
Canada	1,257	1,266	[e] 1,275
Jamaica (exports)	1,997	2,355	2,378
United States	7,213	6,976	7,568
South America:			
Brazil	184	212	[e] 220
Guyana	342	287	[e] 300
Surinam	1,407	1,519	[e] 1,520
Europe:			
Czechoslovakia [e]	80	80	80
France	1,339	1,226	1,397
Germany, East	52	50	50
Germany, West	911	1,010	998
Greece	511	[e] 513	[e] 530
Hungary	515	573	722
Italy	[r] 289	227	[e] 532
Romania [e]	231	231	311
U.S.S.R. [e]	[r] 2,300	[r] 2,500	2,600
United Kingdom	109	128	138
Yugoslavia	136	149	[e] 193
Africa: Guinea	733	731	678
Asia:			
China, People's Republic of [e]	300	310	320
India [e]	[r] 394	400	345
Japan	1,767	1,813	2,190
Taiwan	47	58	[e] 63
Oceania: Australia	[r] 2,990	3,382	4,437
Total	[r] 25,104	25,996	28,845

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition to the countries listed, Austria produces alumina (fused aluminum oxide), but output is used entirely for abrasives production. Production was as follows in short tons: 1971—30,011; 1972—28,943; 1973—31,110.

Table 19.—World producers of alumina

(Thousand short tons)

Country, company, and plant location	Capacity, yearend 1973	Ownership
NORTH AMERICA		
Canada: Aluminum Company of Canada Ltd. Arvida, Quebec	1,387	Alcan Aluminium Ltd. 100%.
Jamaica:		Alcan Aluminium Ltd. 100%.
Alcan Jamaica Ltd.:		
Ewarton, St. Catherine	624	
Kirkvine, Manchester	615	
Alcoa Minerals of Jamaica, Inc. Woodside, Clarendon	551	Aluminum Co. of America 100%.
Alumina Partners of Jamaica, Nain, St. Elizabeth	1,300	Reynolds Metals Co. 36.8%; Anaconda Aluminum Co. 36.8%; Kaiser Aluminum & Chemical Corp. 26.4%.
Revere Jamaica Alumina, Ltd., Maggotty, St. Elizabeth	220	Revere Copper & Brass Inc. 100%.
Total Jamaica	3,310	
United States (see table 6)	7,760	
Total North America	12,457	
SOUTH AMERICA		
Brazil:		
Alumínio Minas Gerais, S.A., Saramenha, Minas Gerais	100	Alcan Aluminium Ltd. 100%.
Cia. Brasileira de Aluminio, S.A., Sorocaba, São Paulo	110	Industria Votorantim, Ltd. 80%; Government, 20%.
Cia. Mineira de Alumínio, Poços de Caldas, Minas Gerais	[e] 75	Aluminum Co. of America 50%; Hanna Mining Co. 23.5%; Brazilian interests 26.5%.
Total Brazil	285	

See footnote at end of table.

Table 19.—World producers of alumina—Continued

(Thousand short tons)

Country, company, and plant location	Capacity, yearend 1973	Ownership
SOUTH AMERICA—Continued		
Guyana: Guyana Bauxite Co., MacKenzie	385	Government 100%.
Surinam: Surinam Aluminum Co., Paranam	e 1,460	Aluminum Co. of America 100%.
Total South America	2,130	
EUROPE		
Czechoslovakia: Ziar, Banskobystricky	143	Government 100%.
France:		
Péchiney Ugine Kuhlmann Group:		Self 100%.
Gardanne	815	
Salindres	290	
La Barasse	330	
Total France	1,435	
Germany, East: V.E.B., Lauta	70	Government 100%.
Germany, West:		
Aluminium Oxid Stade GmbH, Stade	661	Vereinigte Aluminium 50%; Reynolds 50%.
Gebrueder Giulini GmbH, Ludwigshafen	143	Self 100%.
Martinswerke GmbH für Chemische und Metallürgische Produktion, Bergheim	420	Swiss Aluminium Ltd. (Alusuisse) 99.2%.
Vereinigte Aluminium-Werke A.G.:		Government 100%.
Lippenwerke, Lünen	474	
Nabrewerk, Schwandorf	231	
Total West Germany	1,929	
Greece: Aluminium de Grèce S.A., Distomon	529	Péchiney Ugine Kuhlmann Group 90%; Government 10%.
Hungary:		
Ajka I	720	Government 100%.
Ajka II		
Almasfuzito		
Magyarovar		
Total Hungary	720	
Italy:		
Montecatini-Edison S.p.A., Porto Marghera	231	Self 89%; Government 11%.
Eurallumina S.p.A., Porto Vesme, Sardinia	661	Alsar S.p.A. 41.67%; Comalco 20%; Metallgesellschaft A.G. 17.5%; Montecatini-Edison S.p.A. 20.83%.
Total Italy	892	
Romania:		Government 100%.
Oradea	231	
Tulcea	276	
Total Romania	507	
U.S.S.R.:		Government 100%.
Achinsk	e 3,500	
Kamensk-Uralsky		
Kandalaksa		
Kirovabad		
Krasnoturinsk		
Kovo Kuznetsk		
Pavlodar		
Pikalevo		
Sumgait		
Volgograd		
Volkhov-Tikhiun		
Total U.S.S.R.	e 3,500	
United Kingdom: The British Aluminium Co., Ltd., Burntisland	110	Tube Investments, Ltd. 52%; Reynolds 48%.
Yugoslavia:		Government 100%.
Titograd	220	
Kidricevo	154	
Total Yugoslavia	374	
Total Europe	10,209	
AFRICA		
Guinea: Friguia Kimbo	772	Frialco Co. 51%; Government 49%. (Frialco: Olin Corp. 38.5%; Péchiney 36.5%; British Aluminium 10%; Alusuisse 10%; Vereinigte Aluminium 5%).
Total Africa	772	

See footnote at end of table.

Table 19.—World producers of alumina—Continued

(Thousand short tons)

Country, company, and plant location	Capacity, yearend 1973	Ownership
ASIA		
China, People's Republic of:		Government 100%.
Antung		
Fushun		
Hofei		
Kunming		
Kweiyang	e 330	
Lianshui		
Nanting		
Weinan		
Yangshuan		
Total China, People's Republic of	e 330	
India:		
Aluminium Corp. of India, Ltd., Jaykaynagar, West Bengal	28	Self 100%.
Bharat Aluminium Co., Korba, Madhya Pradesh	220	Government 100%.
Hindustan Aluminium Corp. Ltd., Renukoot, Uttar Predesh	182	Birla and Indian interests 73%; Kaiser 27%.
Indian Aluminium Co.:		Alcan 55%; Government 45%.
Muri, Bihar	85	
Belgaum, Mysore	125	
Madras Aluminium Co. Ltd., Mettur, Tamil Nadu	55	Madras State Government 73%; Montecatini-Edison 27%.
Total India	695	
Japan:		
Mitsui Alumina Co., Wakamatsu	220	Mitsui Group 98.5%; other Japanese interests 1.5%.
Nippon Light Metal Co. Ltd.:		Alcan 50%; Japanese interests 50%.
Shimizu	595	
Tomakomai	367	
Showa Denko K.K., Yokohama	600	Self 100%.
Sumitomo Chemical Co., Ltd., Kikumoto	844	Self 100%.
Total Japan	2,626	
Taiwan: Taiwan Aluminium Corp., Kaohsiung, Takao	84	Government 100%.
Turkey: Seydisehir	220	Government 100%.
Total Asia	3,955	
OCEANIA		
Australia:		
Alcoa of Australia (W.A.) Ltd.:		Aluminum Co. of America 51%; Australian interests 49%.
Kwinana, Western Australia	e 1,325	
Pinjarra, Western Australia	e 800	
Nabalco Pty., Ltd., Gove, Northern Territory	1,100	Swiss Aluminium Australia Ltd. 70%; Gove Alumina Ltd. 30%.
Queensland Alumina Ltd., Gladstone, Queensland	2,205	Kaiser 37.3%; Alcan 22%; Péchiney 20%; Comalco 11.3%; Conzinc Riotinto of Australia, Ltd. 9.4%, (Comalco: Conzinc Riotinto of Australia 45%; Kaiser 45%, public 10%).
Total Oceania	5,430	
Total World	34,953	

e Estimate.

1974, first shipments of bauxite by 1977, and eventual export of over 3 million tons per year. Brazilians will own 51% of the venture and foreign companies 49%.

Plans to enlarge two alumina plants by 1976 have been reported. Companhia Mineira de Alumínio was expected to increase annual capacity at its Poços de Caldas plant to 154,000 short tons. Companhia Brasileira de Aluminio, S.A. planned to increase capacity of its Sorocaba plant to 173,000 tons.

Fiji.—Bauxite Fiji Ltd., owned by three Japanese aluminum producers, terminated plans to develop bauxite deposits on the island of Vanua Levu. Construction of production facilities was near completion but was abandoned because of rising costs.

Germany, West.—Aluminium Oxid Stade GmbH., owned jointly by Reynolds International, Inc., and Vereinigte Aluminium-Werke A.G. (VAW), completed construction of a new alumina plant at Stade. The plant has a capacity of 661,000 tons per year and may be expanded.

Ghana.—As a result of a new government policy that Ghana hold a majority interest in mining investments, British Aluminium Co. Ltd. and the Government agreed to form Ghana Bauxite Co. in which the Government would hold 55% of the equity shares and British Aluminium, 45%. British Aluminium has been the only bauxite producer in Ghana and has exported all of its production.

Greece.—Eight companies reportedly mined bauxite, all of which was produced in the Province of Central Greece. Bauxite was again the largest mineral export of Greece. Export quotas for 1973 were established as follows: European Economic Communities, 458,000 long tons; U.S.S.R., 443,000 tons; United Kingdom, 74,000 tons; United States, 74,000 tons; Sweden, 69,000 tons; Spain, 49,000 tons; five other countries, 79,000 tons.

Aluminium de Grèce S.A., a subsidiary of Péchiney Ugine Kuhlmann (PUK), was the only producer of alumina in Greece. Plans for several other alumina plants continued to be negotiated, but no final construction agreements had been concluded at yearend. The Government announced that it had agreed in principle on a joint venture wtih Alcoa to build alumina and aluminum plants near Megara. The venture, in which Alcoa would have a 60% interest and the Government 40%, would include an alumina plant with an annual capacity of 287,000 short tons which could eventually be doubled. Reynolds Metals Co. reportedly received Government approval for a 500,000-ton-per-year alumina plant to be located on the northern shore of the Gulf of Corinth. Reynolds would be associated with Bauxite Parnasse Mining Co. in this project.

Guinea.—The first shipload of high-grade bauxite from the large Boké project left the new port at Kamsar in early August. Production was scheduled at 4 to 5 million tons in 1974 and 9 million tons by 1979. The bauxite is mined at Sangaredi and shipped about 80 miles by rail to Kamsar where it is crushed and dried before exportation. Boké is operated by Guinea Bauxite Co. (CBG), which is owned by the Government of Guinea (49%) and Halco (Mining), Inc. (51%), a consortium consisting of Alcoa (27%), Alcan (27%), Martin Marietta Aluminum, Inc. (20%), PUK (10%), VAW (10%), and Montecatini-Edison S.p.A. (6%). The Government receives 65% of the profits of CBG.

Compagnie International pour la Production de l'Alumine (FRIA) was the only other producer of bauxite in Guinea in 1973 and the only producer of alumina in Africa. The name of the company was changed to Friguia during the year when the Government acquired a 49% ownership of the enterprise. The remaining 51% was owned by the Frialco Co. consortium, consisting of Olin Corp. (38.5%), PUK (36.5%), British Aluminium (10%), Alusuisse (10%), and VAW (5%).

Bauxite deposits at Debele in the Kindia Region were being developed by the Government with assistance from the U.S.S.R. Ore was to be shipped about 70 miles by rail to Conakry for export to the U.S.S.R. Production was expected to be at the level of 2.5 to 3.0 million tons per year. Initial shipments were delayed until 1974.

Hungary.—A new bauxite mine, Rakhegy II, near Lake Balaton in Transdanubia was opened and was expected to produce 350,000 tons per year.

India.—The alumina plant at Korba, Madhya Pradesh, of the government-owned Bharat Aluminium Co. was reported to have come onstream in April. The plant, with an annual capacity of 220,000 short tons per year, will use bauxite from Amarkantak and Phutkapahar. The State Government of Gujarat announced plans for an export-oriented plant of similar size to be located at Bhuj in the Kutch area. The bauxite is to be mined by Gujarat Mineral Development Corp.

Indonesia.—P.N. Aneka Tambang, a government-owned mining company, announced that it had increased its bauxite production and shipping capacity on Bintan Island. Exports to Japan, its principal customer, were to be increased from 1.0 million tons per year to 1.2 million tons. Reserves on Bintan have been estimated at 78 million tons. Following extensive exploration, Alcoa announced its intention to develop bauxite deposits on Kalimantan

(Indonesian Borneo) and to build a large alumina plant.

Jamaica.—Jamaica, the world's second largest producer of bauxite, was also the fourth largest alumina producer. Alcoa's new alumina plant was reported to have reached capacity production, but operating difficulties were encountered at the new plants operated by Alumina Partners of Jamaica, (Alpart) and Revere Jamaica Alumina, Ltd.

In addition to the bauxite produced in Jamaica to supply the five alumina plants on the island, Jamaican bauxite is exported by Kaiser Bauxite Co., Reynolds Jamaica Mines Ltd., and Alcoa. Production by Kaiser was interrupted for half of September because of a dispute over a labor contract. Reynolds was reportedly expanding bauxite capacity from 2.5 to 3.25 million tons per year.

Japan.—Japan's imports of bauxite increased 4% in 1973 and came from five sources, as follows:

Supplier	Quantity (thousand long tons)	
	1972	1973
Australia:		
Comalco Ltd	2,177	2,012
Nabalco Pty. Ltd. (Gove)	534	926
Indonesia: P.N. Aneka Tambang	1,089	997
Malaysia:		
Ramunia Bauxite Co	220	242
Southeast Asia Bauxites Ltd	475	507
Total	4,495	4,684

Sumitomo Chemical Co., Ltd., announced that the annual capacity of its alumina plant at Kikumoto would be increased to 955,000 tons by 1975.

Romania.—Production began at a new alumina plant at Tulcea. Production was not expected to reach full capacity of 276,000 tons until 1975.

Spain.—Plans were disclosed for the construction of an alumina plant in the area of Villagarcia de Arosa, Galicia, on the northwest coast. The plant would eventually have a capacity of 880,000 tons per year, and initial production was expected by 1977. The plant would be operated by a firm formed by two Spanish aluminum-producing companies, Empresa Nacional del Aluminio S.A. (Endasa), 55%, and Aluminio de Galicia S.A. (Alugasa), 45%. Endasa is owned by an agency of the Spanish Government, Institute Nacional de Industria (75%), and Alcan (25%). Alugasa is owned by Péchiney Ugine Kuhlmann and Spanish interests.

Surinam.—Bauxite was mined by Surinam Aluminum Co. (Suralco), an Alcoa subsidiary, and Billiton Maatschappij Suriname N.V. Suralco also produced alumina and aluminum and converted bauxite to alumina for Billiton. Reynolds Metals Co., under a 1971 joint agreement with the Government, continued bauxite exploration activities in the Bakhuys Mountains in western Surinam.

An agreement was signed in August under which Billiton is to bring its assets into the formation of a new corporation, Billiton Suriname, N.V., in which the Government will participate up to 25%. Billiton also is to take part up to 25% in the capital of the Government company of N.V. Grasshopper Aluminium Co. (Grassalco). The new Billiton company and Grassalco will form a joint venture to develop bauxite and other mineral deposits.

Alcan Aluminium Ltd. and Billiton International Metals B.V. began a feasibility study for a joint project to produce refractory-grade calcined bauxite, based on Billiton's reserves. Depending on the outcome, possible annual production was foreseen at 150,000 tons, beginning in 1976.

Turkey.—Production began at the new Seydisehir alumina plant in March 1973. Over half of the output of the 220,000-ton-per-year plant will be used at a nearby aluminum plant when it is put into operation. Most of the remaining alumina is to be exported to the U.S.S.R., which assisted in financing the complex. Bauxite exports to the U.S.S.R. during the year were reported at 150,000 tons.

United Kingdom.—British Aluminium was phasing out alumina production at its Newport plant and expected to close the plant early in 1974. Its Burntisland plant was being converted entirely to the production of nonmetallurgical grades of alumina.[5] Bauxite for the plant has been imported mainly from the company's mines in Ghana.

Yugoslavia.—Construction was reported to have begun on an alumina plant near Obrovac in northern Dalmatia. The plant will have a designed capacity of 330,000 tons per year. Hungary and East Germany will provide part of the equipment and financing for the plant.

[5] Metal Bulletin Monthly. New Lease of Life for Burntisland. No. 36, December 1973, pp. 41, 43.

TECHNOLOGY

Aluminum resources in the United States were assessed by the U.S. Geological Survey.[6]

In December a joint venture of Earth Sciences. Inc., National Steel Corp., and Southwire Co. began test production of alumina from alunite in a new pilot plant at Golden, Colo. The group was reported to have extensive alunite reserves near Cedar City, Utah.

The Bureau of Mines evaluated a sulfurous acid-sulfuric acid process for recovering alumina from clay. The process appeared to be less attractive economically than some alternate techniques of producing alumina from clay.[7] The Bureau initiated a project at Boulder City, Nev., to test and evaluate the most promising processes for recovering alumina from domestic nonbauxitic raw materials. A small-scale continuous pilot plant was under construction, and industry was being invited to support the program. The first process to be investigated will be a nitric acid leach of kaolinitic clay.

Methods for determining nahcolite and dawsonite content in oil shales were investigated and evaluated.[8]

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[6] Patterson, S. H., and J. R. Dyni. Aluminum and Bauxite. Ch. in United States Mineral Resources. U.S. Geol. Survey Prof. Paper 820, 1973, pp. 35–43.

[7] Barrett, P. J., P. W. Johnson, and F. A. Peters. Methods of Producing Alumina From Clay, An Evaluation of a Sulfurous Acid-Sulfuric Acid Process. BuMines RI 7758, 1973, 40 pp.

[8] Huggins, C. W., T. E. Green, and T. L. Turner. Evaluation of Methods for Determining Nahcolite and Dawsonite in Oil Shales. BuMines RI 7781, 1973, 21 pp.

Beryllium

By E. Chin[1]

Domestic production of beryl ore increased in 1973, and one mining company, which mined bertrandite, recovered and stockpiled sufficient ore to maintain a 2-year supply for its operation. The demand for beryllium metal, which is used principally in military and aerospace applications, weakened in 1973. However, a strong demand for beryllium-copper alloys and beryllium oxide ceramics was reflected by increased sales and shipments of those products. The Government's Poseidon missile program, which has been a large user of beryllium components, passed its peak, and the industry did not receive orders for the 1974 requirements for beryllium components.

Table 1.—Salient beryllium mineral statistics

	1969	1970	1971	1972	1973[p]
United States:					
Beryl, approximately 11% BeO:					
Shipped from mines ------short tons--	W	W	W	W	W
Imports ------do------	6,422	4,942	4,026	3,345	1,586
Consumption[1] ------do------	8,483	9,496	10,373	7,781	8,695
Price, approximate, per unit BeO imported, cobbed beryl at port of exportation ------	$37	$35	$33	$30	$30
Bertrandite ore: Utah, low-grade, shipped from mines ------short tons--	W	W	W	W	W
World production of beryl ------do------	8,869	6,857	[r]5,791	4,634	4,291

[p] Preliminary. [r] Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Includes some bertrandite ore which was calculated as equivalent to beryl containing 11% BeO.

Legislation and Government Programs.— In 1973, the Office of Preparedness removed beryl and beryllium-copper master alloy from the list of strategic and critical materials, and the stockpile objectives for these items were abolished. The stockpile objective for beryllium metal was reduced from 150 short tons to 88 short tons. Government inventories of beryl decreased 487 short tons during 1973 as a result of stockpile disposals.

As the result of public hearings held by the Environmental Protection Agency in 1972, emission standards for beryllium were published in the Federal Register on April 6, 1973. The beryllium emission standards cover extraction plants, foundries, ceramic manufacturing plants, machine shops (processing beryllium or beryllium alloys containing more than 5% beryllium), and disposal of beryllium-containing waste. The standards for sources of beryllium dust, fume, or mist emission into the atmosphere were established to insure that ambient concentrations of beryllium would not exceed daily 0.01 microgram per cubic meter, based on a 30-day average.

[1] Physical scientist, Division of Nonferrous Metals—Mineral Supply.

Table 2.—Government yearend stocks of beryllium materials

(Short tons)

Material	National stockpile	Supplemental stockpile	All stocks
Beryl (11% BeO):			
Excess ---------	15,787	2,841	18,628
Beryllium-copper master alloy:			
Excess ---------	1,075	6,312	7,387
Beryllium metal:			
Objective ----	--	88	88
Excess ------	--	141	141
Total ------	--	229	229

Source: General Services Administration. Statistical Supplement, Stockpile Report to the Congress OP-4, July–December 1973, pp. 5–6.

DOMESTIC PRODUCTION

The largest domestic source of beryllium ore was the Spor Mountain bertrandite mine near Delta, Utah. The bulk of the activity in beryl mining was confined to prospecting and assessment work, primarily in Colorado and South Dakota.

During 1973, Brush Wellman, Inc. (Brush), mined sufficient bertrandite to maintain a desired 2-year supply for its operations. Brush's facilities include extraction plants at Delta, Utah, and Elmore, Ohio, to convert bertrandite and beryl, respectively, to beryllium hydroxide. The Elmore plant also has manufacturing and fabrication facilities for beryllium metal, beryllium-copper master alloy and beryllium oxide ceramics shipped in 1973.

Brush expanded its facility at Elmore to provide additional furnace and casting capacity. Brush also is constructing a building at Elmore to house a new rolling mill for beryllium-copper and phosphor-bronze alloys. At Shoemakersville, Pa., Brush installed a new continuous strip annealing line which included furnace, quench, and brushing capability. An 18-inch slitter was added to the beryllium-copper strip line. In early 1974, Brush expected to complete a new facility in Clinton, N.J., to accommodate the expanded demand for beryllium oxide ceramic parts. In midyear, Brush announced the closing of its beryllium metal machining facility at Hayward, Calif.

Kawecki Berylco Industries, Inc. (KBI), used beryl for its primary ore, most of which was imported. The beryl was processed at its Hazelton, Pa., plant. Further processing and fabricating was done at both the Hazelton and Reading, Pa., plants. In 1973, KBI closed its beryllium machining and compacting facility at Yonkers, N.Y. The work done at that plant was to be absorbed by the company's other finishing plants.

KBI installed new mills for the production of precision beryllium-copper strip, and new furnaces for heat treating beryllium-copper at its facilities in Pennsylvania. Additionally, mechanical cleaning equipment was being installed to improve the quality of strip products.

CONSUMPTION AND USES

The beryllium industry consumed beryllium ore equivalent to 8,695 short tons of beryl containing 11% BeO. Because demand for beryllium metal in aerospace and defense programs declined during the year, less metal was shipped in 1973 than in 1972. However, there was an increase in the amount of beryllium-copper master alloy and beryllium oxide ceramics shipped in 1973.

Beryllium metal is used where a high stiffness-to-weight ratio is needed, as in the aerospace industry. It is used for space optical devices, X-ray windows, and airplane brakes, and in missile parts and nuclear structures.

Beryllium-copper alloy products consumed the largest quantity of beryllium. These alloys combine the properties of good electrical and thermal conductivity, strength, hardness, and resistance to fatigue, corrosion, and wear. They are used in an ever-increasing variety of markets such as in the business machine, appliance, transportation, and communication industries. Beryllium-copper alloys are used in electrical and electronic systems for connectors, sockets, switches, and temperature- and pressure-sensing devices to facilitate miniaturization and to provide reliability and long service life.

Beryllium oxide ceramics are used in parts for lasers and microwave tubes, and in semiconductors. Typical applications include power amplifiers for microwave and radio communications, electronic ignition systems, and power regulators such as light-dimming switches.

STOCKS

Consumer stocks of hand-sorted beryl at the end of 1973 totaled 5,894 short tons compared with 6,913 short tons at yearend 1972. Dealers' stocks of beryl are not reported. Stocks of bertrandite are company confidential data.

PRICES AND SPECIFICATIONS

Domestic beryl prices were negotiated between producers and buyers and were not quoted in the trade press. While the price of imported beryl was probably negotiated, the quoted price in 1973 was $30 to $35 per short ton unit. This price range was quoted by Metals Week throughout the year.

Prices for beryllium metal products also remained steady throughout 1973. Beryllium billet was quoted at $70 per pound and 98% powder ranged from $44 to $54 per pound. The yearend price for 5-inch-diameter beryllium rod was $102.82 per pound.

Beryllium-copper master alloy was quoted at $53 per pound. Casting ingot containing 2% to 2.25% beryllium in copper started at $2.06 per pound and dropped in March to $2.035 per pound for the remainder of the year. The quoted base price for Alloy 25 strip was $3.05 per pound at yearend.

FOREIGN TRADE

Exports of beryllium alloys, waste, and scrap in 1973 totaled 109,199 short tons, valued at $1,220,000. For the second consecutive year, the average unit value for beryllium exports was low in comparison with prior years due to increased shipments of beryllium waste and scrap generated from machining operations. The principal destination for this material was Japan.

Imports of beryl decreased for the fourth consecutive year and the quantity received was down 53% from that in 1972. The average unit value for imported beryl was $303 per short ton. About 89% of the beryl imported was from Brazil, the Republic of South Africa, Argentina, and Australia, with Brazil furnishing over one-half of the imports. In addition to the imports of beryl, there were 89 pounds of beryllium metal, wrought, unwrought, and waste and scrap imported, with a value of $889,000.

Table 3.—U.S. exports of beryllium alloys, wrought or unwrought, and waste and scrap[1]

Country	1972		1973	
	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)
Australia	1,270	$5	--	--
Belgium-Luxembourg	3,660	2	--	--
Brazil	1,208	4	4,536	$14
Canada	8,175	56	6,736	104
Denmark	--	--	45	2
France	23,181	83	2,723	132
Germany, West	1,105	19	20,258	137
India	6	1	4	2
Italy	3	1	--	--
Japan	34,025	352	60,412	402
Mexico	271	1	22	1
Netherlands	185	2	17	(2)
Netherlands Antilles	--	--	6,220	18
Norway	14,141	20	--	--
Philippines	1,447	5	--	--
Spain	11	1	--	--
Switzerland	1,963	23	934	25
Taiwan	156	1	2,126	3
United Kingdom	4,685	263	5,166	380
Total	95,492	839	109,199	1,220

[1] Consisting of beryllium lumps, single crystals, powder, beryllium-base alloy powder, and beryllium rods, sheets, and wire.

[2] Less than ½ unit.

Table 4.—U.S. imports for consumption of beryl, by customs district and country

Customs district and country	1972		1973	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Philadelphia district:				
Angola	56	$13	77	$19
Argentina	248	74	138	31
Australia	81	24	116	37
Brazil	1,755	576	862	272
Congo	23	7	--	--
Malagasy Republic	40	13	13	5
Portugal	--	--	13	3
Rhodesia, Southern	65	20	--	--
Rwanda	88	23	67	12
South Africa, Republic of	798	298	300	102
Uganda	98	26	--	--
Total	3,252	1,074	1,586	481
New York City district:				
Angola	55	15	--	--
Australia	16	5	--	--
South Africa, Republic of	22	7	--	--
Total	93	27	--	--
Grand total	3,345	1,101	1,586	481

WORLD REVIEW

Australia.—Seleka Mining and Investments, Ltd. (Seleka), completed an initial drilling program in early 1972 to determine the extent of beryl mineralization at its mine near Perenjori about 200 miles northeast of Perth. By the end of 1972, more than 300 tons of beryl was recovered using small-scale opencut methods. In early 1973, Seleka signed a 5-year contract to supply the entire output of its beryl mine to an unnamed U.S. corporation. The contract was estimated to be around $120,000 per year. The unspecified company reportedly made a substantial interest-free loan to Seleka for the period of the contract.

France.—Tréfimétaux-Berylco S.A., jointly owned by Kawecki Berylco Industries, Inc., and Tréfimétaux, G.P., continued the expansion program at its plant in Coueron. Additional equipment is being added to the beryllium-copper production facilities.

Japan.—As reported by the Japan Society of Newer Metals, N G K Insulators, Ltd., produced beryllium metal, beryllium-copper alloys, and beryllium oxide. Yokosawa Chemical Co., Ltd., produced beryllium-copper alloys and beryllium oxide, while Santoku Metal Industry Co., Ltd., produced beryllium-aluminum alloys. Production data for 1973 were not available. Japan imported beryl principally from Africa, Brazil, and Australia, and beryllium metal scrap from the United States.

Table 5.—Beryl: World production, by country

(Short tons)

Country [1]	1971	1972	1973 p
Angola	--	193	e 10
Argentina	276	e 300	e 300
Australia	r 80	68	e 70
Brazil	2,756	1,710	e 1,650
Malagasy Republic	66	10	e 10
Mozambique	14	9	e 1
Portugal	17	19	e 20
Rhodesia, Southern e	100	65	65
Rwanda	214	e r 130	e 130
South Africa, Republic of	541	276	e 70
Uganda	r 243	68	e 65
U.S.S.R. e	1,400	1,500	1,600
United States	W	W	W
Zaire	84	e 80	e 80
Zambia	--	206	e 220
Total	r 5,791	4,634	4,291

e Estimate. p Preliminary. r Revised. W Withheld to avoid disclosing individual company confidential data.

[1] In addition to the countries listed, the Territory of South West Africa may also have produced beryl, but mineral production from this area has not been officially reported since 1966, and no reliable information is available as a basis for estimating output since that time.

Nepal.—The Nepalese Industrial Development Corp. introduced incentives aimed at attracting foreign investment to exploit the country's mineral wealth. Deposits of interest in the country include beryl near Kathmandu, limestone, magnesite, muscovite, pyrite, and talc.

TECHNOLOGY

Because of the commercial application of beryllium-copper alloys as spring materials, information regarding the stress relaxation behavior of these alloys has significant practical value.[2] Stress relaxation experiments were used as a basis for determining the deformation parameters of a precipitation hardened alloy of copper with 1.87 weight-percent beryllium. The precipitate was found to strengthen the material mainly by increasing the long-range internal stress.

Considerable work was done by the industry in improving beryllium materials through the use of impact grinding of powders and a better understanding of the effect of purity on mechanical properties. These new materials (called S-65 at Brush Wellman and CIP/HIP-1 at KBI) have excellent room temperature and elevated temperature ductility. The minimum room temperature elongation of 3% obtained in these materials is twice that which is obtained in the more conventional grades of beryllium. The stress-strain curve indicates that these materials should be very useful under impact service conditions. The material can be consolidated by either hot pressing or by the CIP/HIP process which consists of cold isostatic pressing, followed by hot isostatic pressing.

Due to the sparse data on sputter-deposited beryllium, an investigation was conducted to obtain information on thick, sputter-deposited beryllium foils.[3] Specimens of sputter-deposited beryllium foils displayed strong textures for a deposition temperature range between 9.5° C and 470° C. The hardness of the deposits ranged from 275 to 800 diamond point hardness. The data indicated that it should be possible to sputter-deposit foils with specific properties.

A simple technique using mesityl oxide was developed for the solvent extraction of beryllium.[4] Mesityl oxide quantitatively extracts beryllium from 0.5 molar hydrochloric acid containing 5 molar potassium thiocyanate. The method is simple, sensitive, selective, and applicable for microgram concentrations of beryllium.

Two patents on the extraction of beryllium values from solutions produced by leaching beryllium ore with acid were issued.[5]

The large beryllium deposits in western Utah are a significant part of the world's beryllium resources.[6] A study conducted by the U.S. Geological Survey determined the mineralogy and chemical composition of the host tuff of the beryllium deposit at Spor Mountain and defined the principal alteration processes responsible for the deposition of the beryllium in the tuff.

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[2] Rohde, R. W., and T. V. Nordstrom. Stress Relaxation of a Copper-1.87 wt. percent Beryllium Alloy. Materials Science and Engineering, v. 12, Nos. 3/4, September/October 1973, pp. 179–185.

[3] Patten, J. W., and E. D. McClanahan. Effects of Deposition Temperature and Substrate Bias on Orientation and Hardness of Thick Sputter Deposited Beryllium Foils. J. Less-Common Metals, v. 30, No. 3, March 1973, pp. 351–359.

[4] Dhond, P. V., and S. M. Khopkaf. Mesityl Oxide as an Extracting Agent for Beryllium. Anal. Chem., v. 45, No. 11, September 1973, pp. 1937–1938.

[5] Grunig, J. K., R. J. Anderson, and B. L. Vance (assigned to The Anaconda Company). Solvent Extraction. U.S. Pat. 3,729,541, Apr. 14, 1973.

Suzuki, H., H. Einaga, and Y. Mori (assigned to the National Institute for Researches in Inorganic Materials). Solvent Extraction. U.S. Pat. 3,751,557, Aug. 7, 1973.

[6] U.S. Geological Survey. Hydrothermal Alteration Associated With Beryllium Deposits at Spor Mountain, Utah. Professional Paper 818-A, 1973, 20 pp.

Bismuth

By John A. Rathjen [1]

Consumption of bismuth in the United States during 1973 rose for the second consecutive year reaching a level of 2.9 million pounds. The largest increase was in metallurgical additives, although fusible alloys and chemical applications also registered strong gains.

The price of bismuth through the year was firm, with several increases reflecting currency fluctuations and strong market conditions. Domestic production was reduced slightly due to the final phaseout of one primary lead smelter, however, this was more than offset by increased imports which were 1.1 million pounds over the 1972 total. World mine production was down nominally reflecting curtailed production in Canada, which was partially offset by gains in Peru.

Legislation and Government Programs.—The General Services Administration (GSA) reported a stockpile inventory at yearend of 2,100,061 pounds of bismuth. The new objective is 95,900 pounds. This indicates a surplus of some 2,004,161 pounds which will require Congressional action for release to the public sector.

Bismuth remained on the list of commodities eligible for aid from the Office of Minerals Exploration (OME), covering 75% of the exploration costs; however, no contracts were in effect during 1973 and no applications were pending.

Table 1.—Salient bismuth statistics

(Pounds)

	1969	1970	1971	1972	1973
United States:					
Consumption	2,531,959	2,209,641	1,648,718	2,315,534	2,906,219
Exports [1]	447,931	910,275	71,187	264,276	151,053
Imports, general	894,804	997,924	848,708	1,562,934	2,676,271
Price: New York, average ton lots	$4.63	$6.00	$5.26	$3.63	$4.92
Stocks Dec. 31: Consumer and dealer	597,901	[2] 721,714	[2] 1,107,215	[2] 717,466	[2] 540,756
World: Production [3]	8,289,000	8,192,000	8,330,000	8,819,000	8,798,000

[1] Includes bismuth, bismuth alloys, and waste and scrap.
[2] Consumer stocks only.
[3] Excludes United States.

DOMESTIC PRODUCTION

Primary production of bismuth in the United States continued to be from the American Smelting and Refining Company (Asarco) Omaha, Nebr., refinery. The raw material input appeared to be split on approximately a 50% basis between those ores and bullions which were of domestic origin and those which were imported for smelting and refining. Roughly 8% of the bismuth production was recovered as a secondary product by United Refining and Smelting Co. at Franklin Park, Ill., and UV Industries, Inc., formerly U.S. Smelting Refining & Mining Co., at East Chicago, Ind.

Individual data relating to U.S. refinery production are withheld to avoid a breach of confidentiality; however, overall production figures were down some 10% in 1973 as compared with 1972 production.

Additional domestic production of bismuth can be expected when The Anaconda Company brings the Victoria mine in Elko

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County, Nev., into full operation. This is a copper mine which has remained idle through the years because of the high bismuth content in the ore which is deleterious to current methods of copper smelting. The perfection of the new hydrometallurgical Arbiter process will now make it possible to separate the copper and the bismuth economically and plans are to bring the complex onstream by 1975. It has been announced that the bismuth in the copper concentrate will run about 0.7%, which indicates that possibly an additional 400,000 pounds of bismuth could be added to the market annually.

CONSUMPTION AND USES

Domestic consumption of bismuth in 1973, at 2.9 million pounds, was the highest recorded figure since 1966 when 3.2 million pounds were consumed. There were increases in virtually all categories with metallurgical additives up 51%, fusible alloys up 24%, and pharmaceutical-chemical applications up 14%.

In spite of the fact that the use of bismuth oxychloride as a cosmetic aid and the use of bismuth-based indigestion remedies were on the decline, overall use of bismuth in the pharmaceutical-chemical area increased, indicating new industrial-commercial applications. The new uses were essentially in catalytic applications for plastics manufacture since exhausted and undesirable uranium-based catalysts were being replaced by newer, more adaptable molybdenum-bismuth compounds.

Increased use of bismuth in the metallurgical field during 1973 was attributed to the extremely high rate of activity in the ferrous and aluminum metals industries where bismuth is used as an aid to the casting of white cast iron and also to improve machinability of certain steels and aluminum.

Increased construction of industrial plants and high-rise complexes, as well as rehabilitation of older buildings where bismuth is used as a low melting point alloy for fire control devices probably accounts for the increased consumption of fusible alloys.

Table 2.—Bismuth metal consumed in the United States, by use
(Pounds)

Use	1972	1973
Fusible alloys [1]	754,432	932,630
Metallurgical additives	549,973	830,928
Other alloys	18,004	15,206
Pharmaceuticals [2]	983,877	1,117,644
Experimental uses	1,105	21
Other uses	8,143	9,790
Total	2,315,534	2,906,219

[1] Includes bismuth contained in bismuth-lead bullion used directly in the production of an end product.
[2] Includes industrial and laboratory chemicals and cosmetics.

STOCKS

Consumer stocks dropped for the second consecutive year to a level of 541,000 pounds as compared with 717,000 pounds in 1972, a reduction of 25% on an annual basis. A quarterly review of the stock position is indicative of the supply-demand picture as it developed through the year. Starting at a level of 717,000 pounds, the figure rose to 907,000 pounds at the March closing. Inventories dropped to 767,000 pounds at the end of June and then climbed to 909,000 pounds at the end of September. A very sharp drop occurred in the fourth quarter to 541,000 pounds or a decrease of 60% in 3 months.

PRICES

Currency fluctuations in addition to strong market requirements were important factors in the increase in domestic prices throughout the year. The January price of $4 per pound was increased to $4.50 in March where it remained until June when a split price of $4.75–$5 was established. In September, the sellers of foreign bismuth raised quotations to $5.50 per pound; this price remained firm until November when the price was further increased to $6.50 per pound resulting in a spread of $5–$6.50 per pound of bismuth metal. In December the Cost of Living Council authorized the domestic producer to increase its price to meet the high level of competition and established a uniform domestic price at $6.50 per pound. At yearend, dealer and foreign prices were highly volatile and the outlook for a price increase in 1974 was probable.

FOREIGN TRADE

Exports of bismuth in all forms during 1973 dropped sharply to a level of 151,000 pounds as compared with 264,000 pounds in 1972, a reduction of some 43%. Shipments were recorded to 18 countries, with six of those representing 94% of the total. In order of declining volume the countries were Canada, 42,000 pounds, (28%); Argentina, 42,000 pounds, (28%); the Netherlands, 21,000 pounds, (14%); Mexico, 14,000 pounds, (9%); the United Kingdom, 13,000 pounds, (8%); and Belgium, 11,000 pounds, (7%).

General imports of metallic bismuth in 1973 reached a record high of 2.7 million pounds. This can be attributed to increased demand, lower domestic production, and cessation of stockpile sales. The principal contributors to imports in quantitative order were Japan, 754,000 pounds, (28%); Peru, 489,000 pounds, (18%); the United Kingdom, 488,000 pounds, (18%); Mexico, 358,000 pounds, (13%); and West Germany, 344,000 pounds, (13%).

Table 3.—U.S. exports of bismuth[1]

Year	Gross weight (pounds)	Value
1970	910,275	$2,332,423
1971	71,187	199,084
1972	264,276	492,585
1973	151,053	446,284

[1] Includes bismuth, bismuth alloys, and waste and scrap.

Table 4.—U.S. general imports of metallic bismuth, by country

Country	1972		1973	
	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)
Belgium-Luxembourg	8,030	$32	58,079	$241
Bolivia	1,164	4	1,410	4
Canada	47,446	163	73,932	345
Ecuador	20,000	94	--	--
France	6,631	19	--	--
Germany, West	42,046	141	343,686	1,627
Japan	191,029	596	754,146	1,255
Korea, Republic of	111,650	339	67,358	280
Mexico	238,660	666	357,796	1,341
Netherlands	r 17,626	r 56	2,517	19
Peru	478,885	1,733	488,751	2,112
South Africa, Republic of	8,000	18	29,994	85
United Kingdom	r 390,638	r 1,371	487,552	2,292
Yugoslavia	1,129	3	11,050	54
Total	1,562,934	5,235	2,676,271	9,655

r Revised.

WORLD REVIEW

The world market for bismuth continued to improve through 1973 resulting in a strong price structure and a changing pattern of international trade. Total production remained steady at 8.8 million pounds in 1973. Bismuth continued to be produced basically as a byproduct of smelting lead, copper, molybdenum, and zinc ores although it was reported that substantial quantities were being returned to the market from secondary treatment of spent catalysts. Bolivia remained the world's largest producer of metal from primary ore.

The First Ordinary General Assembly of the Bismuth Institute convened on April 2 and ended on April 4, 1973. The officers forming the board of directors were elected and the statutes of the Institute were approved.

The principal objectives of the Institute are to develop new applications for the use of bismuth, to increase the use of bismuth in its present applications, and to study patents and publications of relevant technical significance which may lead to a wider use of bismuth. In the first two bulletins, issued in October and December 1973, 48 patent references were cataloged along with a survey of publications, a history of bismuth, and a detailed paper on the use of bismuth in medicine. Charter members included Cerro de Pasco Corp., Peru; Corporación Minera de Bolivia (COMIBOL); Mining & Chemical Products Ltd., United Kingdom; Salsigne S.A., France; Sidech S.A., Belgium; and Peko-Wallsend Ltd., Australia.

The Institute was incorporated in La Paz, Bolivia, and maintains an information center in Brussels, Belgium.

Australia.—Mine production during 1973 was estimated to be some 815,000 pounds. The anticipated surge in production from the Peko-Wallsend Ltd. properties did not occur due to severe flooding which affected both mining operations and smelter construction. The initial program is still in effect and when the program is completed in 1974, an additional 2 million pounds of bismuth might be available to the market. Current production of bismuth from all sources is being exported for smelting and refining with the bulk going to Japan and the balance to Europe.

Bolivia.—Production from all sources in 1973 was estimated to be 1.4 million pounds. Of this, a substantial portion was treated at the Telamayu smelter operated by COMIBOL. A rich bullion produced at the smelter was exported to Europe for refining and ultimate sale in the world market by COMIBOL. The balance of production in the form of ores and concentrates was sold directly to merchants and exported for treatment.

Canada.—Production of bismuth in Canada was reduced sharply in 1973 to 90,000 pounds as compared with 275,000 pounds during 1972. Most of the loss was attributed to curtailed molybdenum production in Quebec where bismuth is recovered as a byproduct. Interruptions at the lead smelter of Cominco Ltd. at Trail, British Columbia, could also account for some of the reduction. The other Canadian bismuth producer, Brunswick Mining and Smelting Corp. Ltd. at Belledune, New Brunswick, was still in the process of converting its furnace facilities.

Mexico.—Bismuth production in Mexico remained stable during 1973 with an estimated 1.4 million pounds, basically the same output as in 1972. The two principal producers were Asarco Mexicana, S.A., and Industrias Peñoles, S.A. at the Met-Mex Peñoles, S.A., plant. Both refineries are located at Monterrey in the State of Nuevo León.

Peru.—Mine production of bismuth in Peru during 1973 increased to a level of 1.7 million pounds as compared with 1.5 million pounds in 1972. During the course of the year Cerro Corp., one of the major world suppliers of bismuth from its refinery at La Oyora, was expropriated by the Peruvian Government and Minèro Peru became the operating and marketing agency for all production at this facility. On December 29, 1973, an official decree was released announcing total Federal Government control and assigning Centromin (a new governmental agency) the operating and marketing responsibilities for the complex. Minèro Peru was to operate and develop the mining facilities.

Table 5.—Bismuth: World mine production by country

(Thousand pounds)

Country [1]	1971	1972	1973 [p]
Argentina (in ore)	(2)	e 1	e 1
Australia (in concentrates)	r 564	796	e 815
Bolivia [3]	r 1,504	1,393	e 1,400
Canada (in ore)	r 271	275	90
China, People's Republic of (in ore) e	550	550	550
France (metal)	170	148	e 155
Germany, West (in ore) e	29	27	25
Japan (metal)	1,790	1,974	e 2,010
Korea, Republic of (metal)	214	212	e 210
Mexico [4]	1,257	1,387	e 1,400
Mozambique (in ore)	3	--	--
Peru [4]	r 1,415	1,492	1,653
Romania (in ore) e	180	180	180
South Africa, Republic of (in concentrates)	(2)	--	--
Spain (metal) e	26	26	26
Sweden (in ore) e	33	33	33
Uganda (in ore)	2	9	e 9
U.S.S.R. (metal) e	120	r 120	120
United States	W	W	W
Yugoslavia (metal)	202	196	121
Total	r 8,330	8,819	8,798

e Estimate. p Preliminary. r Revised. W Withheld to avoid disclosing individual company confidential data.

1 In addition to the countries listed, Brazil, Bulgaria, East Germany, and South West Africa are believed to produce bismuth, but information is inadequate to make reliable estimates of output levels.

2 Less than ½ unit.

3 Production by COMIBOL and exports by medium and small mines.

4 Bismuth content of refined metal, bullion and alloys recovered indigenously, plus recoverable content of concentrates exported for processing.

Boron

By K. P. Wang [1]

Production and domestic consumption of boron minerals continued the rising trend that began in 1961 and reached new highs in 1973. Recorded exports in terms of B_2O_3 content also showed a sharp increase over those of 1972, but lower than the high levels of 1969–70. All U.S. output had been in the form of sodium borates and boric acid. Recently, production of calcium borate (colemanite) was resumed on a small scale in California, the same State that provides the entire domestic production of boron minerals.

Table 1.—Salient boron minerals and compounds statistics in the United States

(Thousand short tons and thousand dollars)

	1969	1970	1971	1972	1973
Sold or used by producers:					
Quantity:					
Gross weight	1,020	1,041	1,041	1,121	1,225
Boron oxide	551	562	568	607	664
Value	81,261	86,827	89,856	95,882	113,648
Imports for consumption: [1]					
Quantity	24	27	7	20	18
Value	718	831	233	626	568

[1] Colemanite only.

DOMESTIC PRODUCTION

Domestic production and sales of boron increased about 9.4% in 1973. As in past years, most of the output came from Kern County, Calif., and to a lesser extent from San Bernardino County, Calif.

At Boron in Kern County, the large open pit mine of U.S. Borax & Chemical Corp., a subsidiary of the British-owned Rio-Tinto Zinc Corp. Ltd., remained the world's foremost source of boron. U.S. Borax produced upgraded crude sodium borates (better than 96% purity), refined borates (including anhydrous borax), and boric acid (including anhydrous boric acid) at the mine site. High-purity and specialty products were produced mainly at Wilmington, Calif., and secondarily at Burlington, Iowa. Wilmington was also the company's port of export. These plants, led by the one at Boron had a combined annual capacity of more than 600,000 short tons of equivalent B_2O_3 in 1973. U.S. Borax maintains a storage center at Botlek in the Netherlands from which borax and borates are shipped to other parts of Europe. All told, the company increased production by nearly 12% during 1973. Crude sodium borates, known by the commercial name of Rasorite, represented about one-half of U.S. Borax's overall output in terms of value and 60% in terms of tonnage.

Kerr-McGee Corp.'s subsidiary, American Potash & Chemical Co., and Stauffer Chemical Co. produced boron compounds as coproducts from brines of Searles Lake in San Bernardino County, Calif., at their adjacent plants in Trona. American Potash's 1973 output was somewhat less than its annual capacity of 100,000 short tons of B_2O_3, and Stauffer Chemical was also producing below its capacity of 25,000 to 30,000 tons of B_2O_3. Both companies increased output by about 10% during the year. In 1973, Kerr-McGee moved ahead on its program to build a $100 million soda ash plant along with possibly additional borate refining facilities.

[1] Supervisory physical scientist, Division of Nonmetallic Minerals—Mineral Supply.

During 1973, Tenneco Oil Co. increased output slightly, although it continued to produce less colemanite than was originally planned, from its deposit in the Furnace Creek district of Inyo County, Calif., and nearby processing plant in Nevada. Tenneco had designed the facilities to produce about 70,000 short tons of calcined colemanite per year, but actually turned out only a fraction of this owing to difficulties in calcining. However, the 48% B_2O_3 grade calcined colemanite found a ready market at the Owens-Corning Fiberglass Corp. plants in Anderson, S.C., and Burkette, Tenn.

CONSUMPTION AND USES

Because of the wide range of products, and the lack of statistics on the large tonnages of crude borates exported, U.S. consumption of boron materials is difficult to estimate. Official U.S. trade statistics do not list crude borate exports separately, and the major domestic producers do not publish details on shipments to foreign countries. It appears however, that shipments of unfinished products to foreign countries were much larger than those of fully refined products, and that a major proportion of U.S. Borax's output of crude borates was shipped to Europe. In general, less than half of the domestic output of boron minerals and compounds was consumed at home, and the remainder was exported.

About 40% or more of the boron compounds consumed domestically, were used in the manufacture of various kinds of glasses. Boron materials account for 5% to 10% of many special glasses by weight and 50% to 75% by value. About 15% of all boron consumed went into insulating fiberglass, 10% into textile fiberglass, and 15% to 20% into all other glasses. Manufacture of enamels, frits, and glazes for protective and decorative coatings on sinks, stoves, refrigerators, and many other household and industrial appliances accounted for another 10% of the boron consumption.

Approximately 15% of the boron compounds consumed in the United States went into soaps and cleaners during 1973, with possibly one-third in the form of sodium perborate detergents. In Europe, on the other hand, sodium perborate detergents used primarily in high-temperature washing account for more than a quarter of all the boron consumed. Borax and boric acid uses in the cleansing field include toothpaste, mouthwash, and eyewash, because of its bactericidal characteristics, easy solubility in water, and excellent water-softening properties.

Borax added to fertilizers to supply boron, an essential plant nutrient, accounted for about 5% of the U.S. boron demand. Another 2% to 3% went into making herbicides. Substituting colemanite for fluorite in steelmaking did not progress much beyond the pilot plant stage.

About one-fourth of the boron consumed in the United States went into many miscellaneous uses. Minor amounts of boron compounds were used as fluxing materials in welding, soldering, and metal refining. Some elemental boron was used as a deoxidizer in nonferrous metallurgy, as a grain refiner in aluminum, as a thermal neutron absorber in atomic reactors, in delayed action fuses, as an ignitor in radio tubes, and as a coating material in solar batteries. Use of boron compounds in abrasives gained ground, particularly cubic boron nitride produced by synthetic diamond producers. Use of boric acid as a catalyst in the air oxidation of hydrocarbons accounted for more than 3% of the boron consumption. Boron materials went into many other areas, including direct consumption in chemicals, conditioning agents or precursors to chemicals, plasticizers, adhesive additives for latex paints, fire retardants, antifreeze, textile and paper products, biocides in jet fuels, photography, and composite materials.

PRICES

Prices of most borate products at yearend 1973 were about 6% more than the prices posted for yearend 1972. Prices of various kinds of borates are shown in table 2.

Table 2.—Borate prices at yearend, 1973

	Price per short ton [1]
Borax, technical:	
Anhydrous, 99%:	
Bags	$119.75
Bulk	109.50
Granular, decahydrate, 99.5%:	
Bags	68.75
Bulk	59.50
Granular, pentahydrate, 99.5%:	
Boric acid, technical: [2]	
Bags	88.75
Bulk	79.75
Anhydrous, 99.9%, bags [3]	197.00
Crystals, 99.9%, bags	253.00
Granular, 99.9%, bags	146.50
Sodium borate powder, U.S.P., bags	117.25

[1] Carlots, f.o.b. plant works.
[2] Technical boric acid $33 per short ton higher in drums.
[3] Anhydrous and granular $10 to $12 per short ton lower in bulk.
Source: Chemical Marketing Reporter and industry sources.

FOREIGN TRADE

U.S. exports of boric acid totaled 41,407 short tons valued at $6.9 million in 1973, as compared with 27,655 tons in 1972. Exports of refined sodium borate increased to 168,826 tons valued at $19.4 million in 1973, from 162,123 tons in 1972. Combined exports of all refined boron compounds was therefore higher than tonnages in 1971 and 1972, although still lower than the previous record levels during 1969–70. As noted, these figures do not tell the whole story because exports of crude borates, not separately recorded, were actually much higher than exports of refined borates.

A detailed breakdown of recorded exports in 1973 is shown in table 3. Within this table, data for all countries outside of Western Europe are accurate.

While the overall total exported to Western Europe is accurate, the quantities shown for individual countries of Western Europe do not reflect the true picture. In table 3, the Netherlands appears as the major recipient of U.S. exports. However, the Netherlands is actually a major transshipment point, and a significant portion of the material shown destined for that country is ultimately shipped to other nearby countries. A more meaningful array of recipient nations, including an estimate for crude borates, would show that West Germany, France, the United Kingdom, Japan, Belgium, Spain, and Italy were the ranking final destinations, in that order; the Netherlands was actually eighth in 1973.

In 1973, the United States imported 18,216 short tons of calcium borate (colemanite) valued at $568,000, all from Turkey. This compares with 20,227 short tons valued at $626,000 during 1972.

Table 3.—U.S. exports of boric acid and sodium borates, in 1973

Destination	Boric acid (H_3BO_3 content)		Sodium borates (refined)	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Australia	4,043	$649	7,510	$796
Belgium-Luxembourg	13	1	52	5
Brazil	1,530	269	658	149
Canada	2,601	381	18,244	1,151
Chile	69	12	135	18
Colombia	279	51	739	89
Costa Rica	45	9	132	14
El Salvador	3	1	75	16
Finland	--	--	179	18
France	--	--	235	24
Germany, West	3,346	490	502	57
Guatemala	14	4	47	6
Hong Kong	186	30	4,585	537
Indonesia	165	18	1,624	148
Israel	3	1	232	25
Italy	178	46	314	39
Japan	14,173	2,264	48,482	5,870
Korea, Republic of	320	60	2,842	238
Malaysia	35	7	542	51
Mexico	1,727	287	7,589	832
Netherlands	7,270	1,437	56,238	7,142
New Guinea	129	25	75	10
New Zealand	319	55	3,194	571
Nicaragua	--	--	35	8
Pakistan	--	--	92	9
Peru	269	32	379	53
Philippines	515	91	875	109
Poland	118	13	--	--
Singapore	171	36	636	68
South Africa, Republic of	110	29	1,482	206
Sweden	242	44	59	4
Switzerland	59	9	146	10
Taiwan	479	88	3,965	424
Thailand	50	10	1,755	176
United Kingdom	2,234	284	471	39
Venezuela	415	75	355	42
Vietnam, South	--	--	2,985	238
Yugoslavia	--	--	342	43
Other	297	54	1,024	119
Total	41,407	6,862	168,826	19,354

WORLD REVIEW

China, People's Republic of.—Large resources of borates reportedly occur in the Iksaydam dried lake area of Tsinghai Province where there is a plant producing mixed salts. National output of borates and boric acid combined may be several tens of thousands of tons annually. The textile fiberglass industry which has been expanded sharply in recent years, consumes a considerable quantity of borates annually. China ships a few thousand tons of surplus borates annually to Japan.

Turkey.—Turkey's 1973 production of boron minerals increased to possibly 250,000 short tons of B_2O_3 content. Actual production is hard to estimate since Turkey has both colemanite (calcium borate) and "tincal" (sodium borate) reserves and was in the process of expanding processing capacity. Because of the extensive reserves and great demand for boron products in world markets, Turkey's relative production position regarding the United States continued to improve. The Government-owned Etibank gained further importance as the principal producer of borates at the expense of Türks Boraks Madençilik A.S. (a subsidiary of Rio-Tinto inc Corp.) and others. The issue of nationalization was not settled at yearend, but it appeared imminent that the "boron" industry would be totally nationalized.

Etibank owns the largest reserves of borates in Turkey and operated some of the most important mines and plants. Under its jurisdiction are both colemanite and tincal deposits. Although details on 1973 data are not available, Etibank's production in 1972 comprised about 190,000 short tons of upgraded colemanite (about 40% B_2O_3 grade) 90,000 short tons of upgraded tincal (perhaps 35% B_2O_3 grade), 30,000 tons of borax, and 12,000 short tons of boric acid. The tincal was used to manufacture borax and boric acid at the Bandirma plant, which was designed and built by Polish engineers around 1968.

The nature of Etibank's operations has undergone steady change. Two colemanite mines were in existence at yearend 1973—an open pit mine, Emet, and an underground mine, Espey, both in Kutahya Province and roughly 215 miles from the port city of Bandirma. Combined known reserves exceed 10 million short tons of 27%–30% ore, but potential reserves are many times larger. A washing plant with a capacity to upgrade 660,000 short tons of ore into 330,000 short tons of product (40%–45% grade) was in full-scale operation at Hisarcik in 1973.

Etibank's tincal deposits were discovered at Kirka only a few years ago. Known reserves are several tens of million tons of ore (26% plus grade), and potential reserves may be more than 10 times greater. A washing plant with an annual capacity of 440,000 short tons of product (35% B_2O_3 grade) was under construction and expected to be completed by the summer of 1974. Tincal from Kirka has replaced colemanite from Kutahya as the principal feed at the Bandirma plant. Plans are underway to eventually build facilities to transform the tincal product to crude borax pentahydrate, crude anhydrous borax, and refined anhydrous borax. These developments will further strengthen Turkey's position in the world as a supplier of boron minerals and products.

U.S.S.R.—As an order of magnitude, the U.S.S.R. may be producing at a rate corresponding to 20% to 30% the U.S. level from reserves that may be half as much. The borate industry of the U.S.S.R. was born in 1934, when several dozen deposits of relatively standard ores were discovered along a fracture zone of a large Permian salt dome in the Inder District, 150 miles north of the Caspian Sea. Other deposits were subsequently discovered in Kazakhstan, the Caucasus, and Siberia. Recently, a complex boron mineralization in the form of azoproit (contains titanium and magnesium also) was found on the western shores of Lake Baikal. The U.S.S.R. has had a surplus of boron compounds, judging from imports made by Japan from the Soviet All-Union Export-Import Agency, Dalintorg. Japan imported 3,725 short tons of boric acid and 52,665 tons of borax (probably penta variety) from the U.S.S.R. during 1973, a little more than average tonnages in 1971–72.

TECHNOLOGY

The use of colemanite as a substitute for fluorspar in the basic oxygen furnace (BOF) steel process made some progress. Widespread application showed little promise because of the adequate world supply of fluorspar and increasing demand for boron minerals in the manufacture of insulating fiberglass. However, despite high costs and some deleterious side effects, colemanite already was used in limited quantities in flux mixes to eliminate sulfur and phosphorus from specialty high-carbon steels.

Oxidation, erosion, wear, and corrosion resistance, as well as hardness, of steel bonded carbides and various grades of steel reportedly can be improved by using a new diffusion process that imparts a layer of boron on the surface of these metals. It was also claimed that various wear and tooling applications are foreseen.[2]

Alkali borate and B_2O_3 glasses containing large concentrations of gaseous noncondensed compounds (including Ar and H_2) were synthesized at high temperatures and pressures, and the solubilities of the gases were determined.[3]

The U.S. Air Force continued its investigation of using boron as part of a fluidized-solids propellant mixture, but have not yet reported its findings.

It was claimed that many reagents derived from boron, such as borane and diborane, exhibited enormous versatility in types of organic synthesis reactions and therefore should be used much more industrially.[4]

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[2] Mal, K. K. and S. E. Tarkan. Diffused Boron Ups Hardness, Wear Resistance of Metals. Mater. Eng., v. 77, No. 4, April 1973, pp. 70–71.

[3] Faile, S. P., and D. M. Roy. Gas Solubility in Relation to the Structures of Glasses and Liquids. J. Am. Ceram. Soc., v. 56, No. 1, January 1973, pp. 12–16.

[4] Chemistry & Industry. Boron Derivatives as Selective Reagents for Organic Synthesis. No. 5, Mar. 3, 1973, pp. 206–210.

Bromine

By Charles L. Klingman [1]

The bromine industry had another record year in 1973, registering an 8.1% increase in the quantity of elemental bromine used or sold, compared with a 7% historic growth rate. Even ethylene dibromide, a gasoline additive, showed a 5.5% increase in spite of a national effort to reduce atmospheric pollution through the use of less tetraethyl lead and ethylene dibromide in gasoline. Greater increases were evidenced in the production of flame retardants and agricultural chemicals. Estimates of bromine and bromine compounds exports were obtained for the first time through a Bureau of Mines survey, and it indicated that about 10% of the U.S. bromine production was exported.

The average unit value of bromine produced, as indicated by reports of bromine producers, dropped about 2.5% in 1973, continuing a trend in price reduction which has persisted for several years. Average production costs were probably reduced by the increased production from Arkansas brines, which are richer than Michigan brines in bromine content.

In 1973, the future of the bromine industry was difficult to predict because of the uncertain position of additives in gasoline. If the additives were reduced by 1979 to 23% of the 1973 usage, as required by Environmental Protection Agency (EPA) regulations, there could be an excess supply of bromine on the market. Certain bromine plants which primarily produce ethylene dibromide might be forced to close or to diversify into the manufacture of other bromine compounds. On the other hand, if EPA regulations were modified, there could be much more demand for bromine than could be supplied by existing facilities.

Legislation and Government Programs.—Regulations issued by EPA during 1973 to reduce the lead content of gasoline for public health protection had a potentially critical effect on the bromine industry. Ethylene dibromide is added to gasoline in direct proportion to the amount of tetraethyl lead contained, and serves as a scavenger to remove lead from automobile engines after combustion. The average lead content of gasoline in 1973 was 2.2 grams per gallon, but EPA rules called for a reduction to an average of only 77% of the 1973 level by the end of 1974. The final goal was to reduce the lead content to an average of 0.5 gram per gallon, 23% of the 1973 level, by January 1, 1979.

In terms of ethylene dibromide production, the proposed 1974 reduction would amount to a loss of 73 million pounds, and the final EPA goal would reduce ethylene dibromide output by 243 million pounds per year. The Ethyl Corp. and others entered a lawsuit against EPA to nullify the 1973 regulations, contending that EPA had not proved that the use of lead in gasoline was detrimental to public health.

Bromine was not considered to be of strategic importance to the United States, and there was no Government-sponsored stockpile for bromine or its compounds. There was a small tariff, however, on imports of bromine and a few bromine compounds.

[1] Physical scientist, Division of Nonmetallic Minerals—Mineral Supply.

DOMESTIC PRODUCTION

Bromine production in 1973, from the leading State of Arkansas increased 13% over that of 1972, continuing the State's historic rise in bromine production. By contrast, Michigan showed about 3.8% decrease in bromine production. Approximately 9.4% of the bromine produced was sold in the elemental form to nonmanufacturers of bromine compounds.

In 1973, there were 10 bromine-producing plants in 3 States operated by 7 companies. Two of these plants confined their operations to the extraction of elemental bromine and did not manufacture compounds.

Table 1.—Elemental bromine sold as such or used in the preparation of bromine compounds by primary producers in the United States

(Thousand pounds and thousand dollars)

	1972		1973	
	Quantity	Value	Quantity	Value
Sold	37,402	6,343	39,203	7,350
Used	349,462	57,346	379,047	59,781
Total	386,864	63,689	418,250	67,131

Table 2.—Bromine compounds sold by primary producers in the United States

(Thousand pounds and thousand dollars)

	1972			1973		
	Quantity			Quantity		
	Gross weight	Bromine content	Value	Gross weight	Bromine content	Value
Ethylene dibromide	316,603	269,334	49,325	333,953	284,013	51,684
Methyl bromide	24,683	20,768	8,381	21,846	18,366	7,560
Other compounds [1]	84,962	58,934	39,770	98,606	68,471	60,444
Total	426,248	349,036	97,476	454,405	370,850	119,688

[1] Includes hydrobromic acid, tetrabromobisphenol, ethyl, ammonium, sodium, potassium, and other bromides.

Table 3.—Domestic bromine producers

State	Company	County	Plant	Production source
Arkansas	Arkansas Chemicals, Inc	Union	El Dorado	Well brines.
	Bromet Co	Columbia	Magnolia	Do.
	The Dow Chemical Co	do	do	Do.
	Great Lakes Chemical Corp	Union	El Dorado	Do.
	Michigan Chemical Corp	do	do	Do.
California	Kerr-McGee Chemical Corp	San Bernardino	Trona	Searles Lake brines.
Michigan	The Dow Chemical Co	Mason	Ludington	Well brines.
	do	Midland	Midland	Do.
	Michigan Chemical Corp	Gratiot	St. Louis	Do.
	Morton Chemical Co	Manistee	Manistee	Do.

CONSUMPTION AND USES

The Bureau of Mines does not survey the consumption of bromine and bromine compounds. From production records, however, it was known that 68% of the 1973 elemental bromine production went to the manufacture of ethylene dibromide. Most of this production was used as a gasoline additive, but the compound was also used as a solvent and in agriculture. In spite of pessimism in the industry over the future of ethylene dibromide as a gasoline additive, its consumption increased by 5.5% in 1973.

New developments in the consumption of bromine were centered around flame retardants and agricultural applications. Flame retardants for plastics provided a growing and potentially profitable outlet for bromine. Agricultural chemicals were led by methyl bromide, a soil sterilant and an insect fumigant. Many bromine-bearing agricultural chemicals were considered to be proprietary in nature.

Elemental bromine was utilized as a disinfectant, as an algaecide, and as an oxidizer in the manufacture of other chemicals.

PRICES

Prices for bromine and certain bromine compounds at yearend were quoted in the Chemical Marketing Reporter as follows:

	Cents per pound
Bromine, purified:	
Cases, carlots,	49
Cases, carlots, truckloads, delivered east of Rocky Mountains	49
Zone I:[1]	
Returnable drums, carlots, truckloads, delivered east of Rocky Mountains	20
Bulk tank car, tanktrucks (45,000-pound minimum), delivered	18
Ammonium bromide, national formulary (N.F.) granular, drums, carlots, truckload, freight equalized	48.0–48.5
Bromochloromethane, drums, carlots, freight equalized	54.5
Tanks, same basis	53
Ethyl bromide, technical, 98%, drums, carlots, freight allowed, East	68
Ethylene dibromide, drums, carlots, freight equalized	25
Tanks, freight equalized	20
Methyl bromide, distilled, tanks, 140,000-pound minimum, freight allowed	34
Potassium bromate, granular, powdered, 200-pound drums, carlots, freight allowed	64–77
Potassium bromide, N.F., granular, drums, carlots	43.5
Sodium bromide, N.F. granular, 400-pound drums, freight equalized	40

[1] Delivered prices for drums and bulk shipped west of Rockies, 1 cent per pound higher. Bulk truck prices 1 cent per pound higher for 30,000-pound minimum and 2 cents per pound higher for 15,000-pound minimum. Price f.o.b. Midland and Ludington, Mich., freight equalized, 1 cent per pound lower.

The average unit price of bulk elemental bromine as evaluated by producers in 1973 was 2.5% less than the 1972 average price, continuing a historic trend toward lower prices.

FOREIGN TRADE

The Bureau of Mines annual survey of bromine producers obtained information, for the first time, on exports of bromine and bromine compounds. The total reported for the United States is known not to include all shipments but is given below for reference:

1973 exports	*Quantity (pounds)*
Bromine in compounds	40,683,000
Elemental bromine	535,000
Total	41,218,000

A review article covering bromine activities in 1973[2] quoted H. W. Andre of the Great Lakes Chemical Corp. as saying that one-third of the U.S. production of ethylene dibromide (100 million pounds) was shipped overseas in 1973.

Imports of bromine compounds remained quite small in 1973, totaling only 57,000 pounds of contained bromine. Imports consisted mostly of potassium bromide and sodium bromide from Israel, France, Canada, and West Germany. Japan also shipped a small amount of ethylene dibromide to the United States in 1973.

WORLD REVIEW

The United States produced and consumed about 70% of the world bromine supply in 1973. The estimated production for other major bromine-producing countries is given in table 4. Bromine reserves in all producing countries are believed to be large, but quantities are unknown. Sea water, of course, provides an unlimited source of bromine at relatively low levels of bromine concentration.

In France, bromine is produced as a coproduct at the potash mines in Mulhouse in the Alsace area. Production from these mines is limited by law to prevent excessive damage to the ecology.

Israel has virtually unlimited resources of bromine in the waters of the Dead Sea, but the unstable political situation in that area has prevented extensive increases in present bromine production.

The United Kingdom is supplied with bromine in the waters of the Dead Sea, but tion on British bromine production is concealed to avoid disclosure of company confidential data. Very few mineral production facts are available from any of the Soviet bloc countries. Bromine production in the U.S.S.R. is indirectly estimated from related data at about 28 million pounds per year.

[2] Chemical & Engineering News. Bromine Outlook Tied to Clean Air Rules. V. 52, No. 8, Feb. 25, 1974, pp. 11–12.

Table 4.—Bromine: World production, by country[1]

(Thousand pounds)

Country[2]	1971	1972	1973[p]
France	32,033	29,895	[e] 31,000
Germany, West[e]	5,700	6,000	6,600
India	538	[e] 550	[e] 550
Israel	26,799	30,865	[e] 26,500
Italy[3]	11,515	[e] 11,500	[e] 11,500
Japan	20,726	23,093	24,300
Spain[e 4]	880	880	880
United Kingdom	52,470	66,139	[e] 66,200
United States	355,946	386,864	[e] 421,000

[e] Estimate. [p] Preliminary.

[1] Owing to incomplete reporting, this table has not been totaled.

[2] In addition to the countries listed, several other nations may also produce bromine (including, most notably, the U.S.S.R.), but output data are not reported and no basis is available for estimating output levels.

[3] Elemental bromine from thermal and marine waters only; additional bromine may be produced in the form of compounds and/or as elemental bromine from other sources.

[4] Spanish bromine production was officially reported to be 32 metric tons in 1971, but according to other Spanish sources, this figure is low, excluding quantities of elemental bromine that were consumed by the manufacturing firms in the process of producing bromine compounds. The Advisory and Technical Studies Commission of the Spanish Chemical Industry (Comisión Asesora y de Estudios Téchnicos de la Industria Quimica Española) indicates that 1971 output was of the order of 400 metric tons, and that productive capacity totaled 1,500 metric tons (source: La Industria Quimica en España 1971, Madrid, 1972, pp. 38–39). No later published figures are available.

TECHNOLOGY

Two scientists of The Dow Chemical Co. discovered[3] that bromine chloride was a more active brominating agent and was much less corrosive than bromine. Both chemicals required the presence of moisture to develop their corrosive nature, but moist bromine was found to be much more corrosive than bromine chloride.

An advance in pacemaker batteries was announced by General Electric Co.[4] The cell had a bromine cathode, a sodium-amalgam anode, and a beta-alumina ceramic electrolyte. Its expected life was about 10 years.

One increasing use for bromine was as a reagent to produce brominated vegetable oil, BVO.[5] This soybean-oil-based product was used mainly by soft drink producers to adjust the density and cloudiness of citrus flavorings. The safety aspects of BVO were under investigation by the U.S. Food and Drug Administration in 1973. Less than 1 million pounds of BVO per year were manufactured.

[3] Chemical Engineering. Bromine Chloride: Less Corrosive Than Bromine. V. 80, No. 18, Aug. 6, 1973, pp. 102–106.

[4] Chemical & Engineering News. Concentrates. V. 51, No. 43, Oct. 22, 1973, p. 12.

[5] Chemical Week. The Safety Aspects of Brominated Vegetable Oil. V. 113, No. 21, Nov. 21, 1973, p. 13.

Cadmium

By J. M. Hague [1]

Declining domestic production of cadmium continued to reduce the percentage of United States self-sufficiency in a period of expanding domestic and world demand. Of 6,228 tons of cadmium apparently consumed in the United States in 1973, only about 32% came from domestic mines. U.S. zinc smelters produced 60% of the cadmium supply from a mixture of domestic and imported materials; net metal imports accounted for 29%, the Government stockpile 6%, and drawdown of industry stocks 5% of supply. Six companies produced primary cadmium at eight domestic plants. Canada was the major source of imported metal and concentrates. Price increases for cadmium during 1973, from $3 per pound to $3.75 per pound, were moderate when compared with other nonferrous metals. The unit of measure for statistical data contained in this chapter has been changed to short tons from the thousand pound measure used in previous editions.

Legislation and Government Programs.—Sales from the national stockpile administered by the General Services Administration (GSA) were 385 tons (770,405 pounds) in 1973. At the end of the year, the total stockpile inventory was 4,242 tons, including 21 tons already committed, the objective for retention was 2,223 tons, and the quantity available for disposal was 1,221 tons. Prices for GSA sales were at current producer prices for balls, and 5 cents below the producer price for sticks, f.o.b. storage locations in lots of 2,000 pounds or more.

In April 1973, the Office of Preparedness revised the stockpile objective for cadmium from 3,000 tons to 2,223 tons. A bill, H.R. 9596, was introduced in the Congress in July to authorize the release of this difference, 777 tons, from the national stockpile. No hearings had been held on this bill by the end of 1973. The previous authorization under Public Law 91–314 provided for the releases made throughout the year.

Phase 4 price controls were applied to cadmium by the Cost of Living Council on June 13, 1973, and were removed on December 6, 1973; the quoted price remained at $3.75 per pound throughout this period, and continued at that figure after the control was lifted.

Exploration cost assistance for cadmium is available from the Office of Minerals Exploration with 50% of allowable costs furnished by Government participation. No contracts were sought or active in 1973.

[1] Mining engineer, Division of Nonferrous Metals—Mineral Supply.

Table 1.—Salient cadmium statistics

(Short tons)

	1969	1970	1971	1972	1973
United States:					
Production [1]	6,323	4,732	3,965	4,145	3,714
Shipments by producers [2]	6,489	3,424	3,887	5,240	4,304
Value ____thousands__	$40,636	$24,163	$9,823	$18,965	$23,891
Exports	542	187	33	509	153
Imports for consumption, metal	539	1,246	1,749	1,211	1,946
Apparent consumption	7,531	4,531	5,436	r 6,313	6,228
Price: Average per pound [3]	$3.27	$3.57	$1.92	$2.56	$3.64
World: Production	19,392	18,227	r 17,007	r 18,388	18,747

r Revised.
[1] Primary and secondary cadmium metal. Includes equivalent metal content of cadmium sponge used directly in production of compounds.
[2] Includes metal consumed at producer plants.
[3] Average quoted price for cadmium sticks and balls in lots of 1 to 5 tons.

DOMESTIC PRODUCTION

Domestic production of cadmium continued at a rate slightly below the 1972 pace, diminishing in each quarter until the fourth, which showed a recovery to a quarterly rate close to 950 tons. The long-term decline in cadmium production was an expected result of declining zinc production, but the two do not show a direct correlation owing to stockpiling of intermediate products and variations in cadmium content of zinc concentrates received by zinc-cadmium producers. Total production for 1973 was 3,714 tons, a decrease of 10% from the 1972 level. Shipments exceeded production as stocks were drawn down, and the value of shipments increased 26% to $24 million, mostly because of price increases early in the year.

Imports of flue dust from Mexico decreased 78% from the 1972 rate, further decreasing the supply of raw material for domestic producers. Imports of zinc concentrate decreased 22%, which also reduced the cadmium content available for domestic recovery.

The cadmium content of sulfide compounds produced (including cadmium sulfoselenide and cadmium lithopone) increased 4% over the level of the previous year, reaching a 38% share of total domestic production.

Cadmium oxide was produced at two plants and cadmium metal was produced at eight plants, all owned by six companies; secondary cadmium was remelted or refined at one secondary metal plant.

Table 2.—Cadmium sulfide[1] produced in the United States

(Short tons)

Year	Sulfide[2] (cadmium content)
1969	1,220
1970	1,068
1971	1,118
1972	1,357
1973	1,412

[1] Cadmium oxide withheld to avoid disclosing individual company confidential data.

[2] Includes cadmium lithopone and cadmium sulfoselenide.

CONSUMPTION AND USES

The apparent consumption of cadmium, a total of 6,228 tons, was little changed from the 1972 consumption. (See figure 1.) Government sales continued to contribute substantially to the total supply.

Metal used for electroplating parts for appliances, motor vehicles, machinery, and hardware probably accounted for slightly less than half of U.S. consumption. Compounds used as colorants (red, orange, yellow) in paints and frits, and compounds used as stabilizers in plastics accounted for about one-third of the total usage. Nickel-cadmium and silver-cadmium batteries, alloys, cadmium phosphors, and other uses accounted for the one-sixth remainder.

Table 3.—Apparent consumption of cadmium

(Short tons)

	1972	1973
Stocks—beginning	r 2,649	1,662
Production	4,145	3,714
Imports, metal	1,211	1,946
Government sales	479	385
Total (supply)	r 8,484	7,707
Exports	509	153
Stocks—end	r 1,662	1,326
Apparent consumption[1]	r 6,313	6,228

r Revised.

[1] Total supply minus exports and yearend stocks.

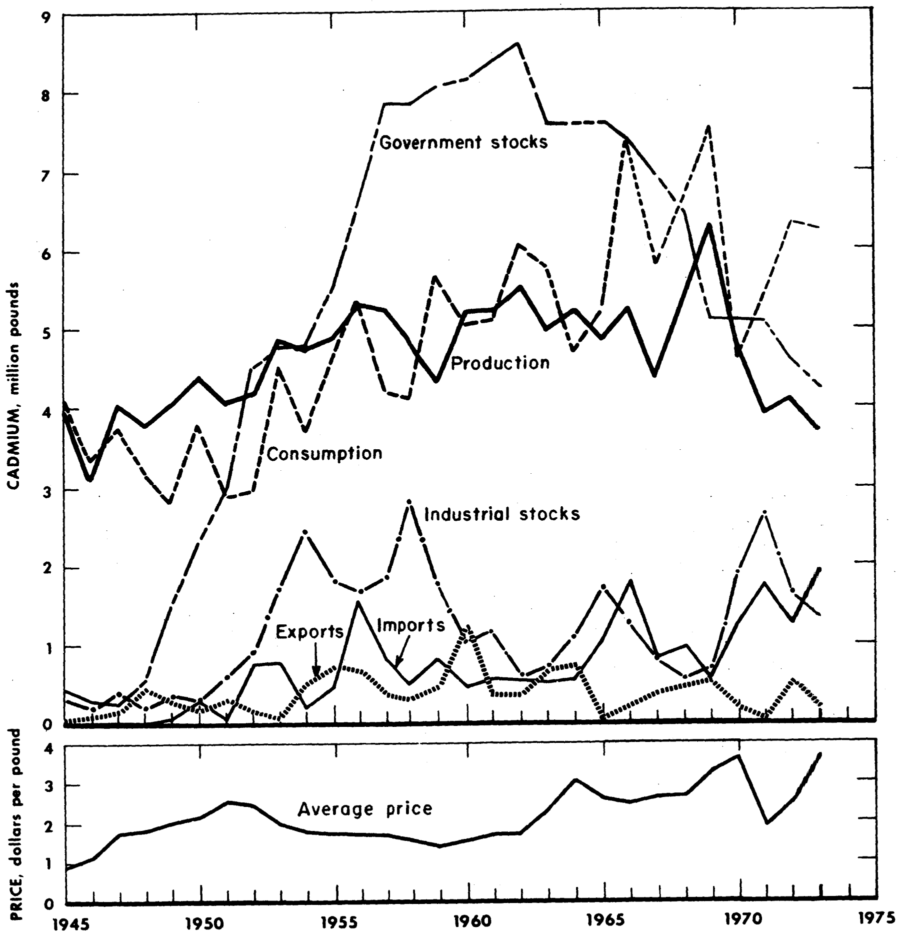

Figure 1.—Trends in production, consumption, yearend stocks, exports, imports, and average price of cadmium metal in the United States.

STOCKS

Stocks held by industry declined 20% in 1973, continuing the decline of 1972. Stocks of cadmium metal and cadmium content of compounds at the end of 1973 totaled 1,326 tons, half of the inventory of 2 years ago. Cadmium remaining in the GSA stockpile, not included in the table, was 4,242 tons, of which 1,221 tons was presently available for disposal.

Table 4.—Industry stocks, December 31

(Short tons)

	1972		1973	
	Cadmium metal	Cadmium in compounds	Cadmium metal	Cadmium in compounds
Metal producers	831	W	456	W
Compound manufacturers	226	466	205	542
Distributors	114	r 25	104	19
Total	1,171	r 491	765	561

r Revised. W Withheld to avoid disclosing individual company confidential data; included with "Compound manufacturers."

PRICES

Producer prices for cadmium at the beginning of the year were $3.00 per pound for 1-ton lots. On January 25, the price was raised to $3.25 per pound by American Smelting & Refining Co. (Asarco); other producers followed this lead the next day. On March 1, Bunker Hill Co. raised its price to $3.50 per pound and Asarco, Cominco, Ltd., and American Metal Climax Inc. (AMAX) then quoted $3.75, but St. Joe Minerals Corp. and The New Jersey Zinc Co. remained at $3.25 throughout March. Early in April all producers moved to the $3.75 per pound quotation, and this quoted price remained unchanged to the end of the year. Dealer prices were 15 to 20 cents below the producer price in much of the second quarter and part of the third quarter, more in line with lower European prices. By the end of the year, U.S. dealer quotations were only 5 to 10 cents under the $3.75 producer price, and the European price was $3.60 to $3.65 per pound.

Table 5.—Cadmium prices, 1973

(Dollars per pound)

Date	Producers' price, 1-ton to 5-ton lots
Jan. 1 to 25	3.00
Jan. 25 to Feb. 28	3.25
March 1 to April 1	3.50–3.75
April 2 to Dec. 31	3.75

FOREIGN TRADE

Exports of cadmium metal and scrap decreased from 509 tons in 1972 to 153 tons in 1973. Principal destinations were as follows: France 43%, Belgium 20%, Japan 13%, and West Germany 11%. Much of the cadmium going to Belgium was probably scrap or secondary material sent for refining in European plants.

Imports of cadmium metal increased by 61% to compensate in part for the marked decrease in imports of flue dust from Mexico. Canada was again the main source of imported metal, accounting for 41% of the total. Other sources of foreign cadmium were Australia 18%, Belgium-Luxembourg 17%, Peru 5%, and others 19%.

No duties are imposed on metal or flue dust imported from most-favored nations, but a statutory duty of 15 cents per pound is levied on cadmium metal imported from communist-bloc countries, except Yugoslavia.

Table 6.—U.S. exports of cadmium metal and cadmium in alloys, dross, flue dust, residues, and scrap

Year	Quantity (short tons)	Value (thousand dollars)
1971	33	172
1972	509	2,363
1973	153	598

Table 7.—U.S. imports for consumption[1] of cadmium metal and cadmium flue dust, by country

Country	1972 Quantity (short tons)	1972 Value (thousands)	1973 Quantity (short tons)	1973 Value (thousands)
Cadmium metal:				
Argentina	4	$21	4	$24
Australia	203	821	359	2,395
Belgium-Luxembourg	109	467	336	2,143
Canada	534	2,322	805	5,553
Chile	--	--	3	19
France	9	25	23	130
Germany, West	37	120	61	351
Ghana	--	--	6	25
Italy	--	--	11	65
Japan	64	177	20	111
Korea, Republic of	--	--	24	162
Mexico	68	196	83	439
Netherlands	18	64	44	288
Peru	148	600	103	698
South Africa, Republic of	16	70	24	159
Spain	1	3	17	104
U.S.S.R.	(2)	(2)	--	--
United Kingdom	--	--	6	35
Yugoslavia	--	--	17	98
Total	1,211	4,886	1,946	12,799
Flue dust (cadmium content): Mexico	370	685	82	243
Grand total	1,581	5,571	2,028	13,042

[1] 1972 and 1973 general imports and imports for consumption were the same.
[2] Less than ½ unit.

WORLD REVIEW

World smelter production of cadmium increased 2.0% to a preliminary total of 18,747 short tons, not equaling the record 19,374 tons produced in 1969. The United States was the largest metal producer with 20% of the total, followed by Japan 18%, U.S.S.R. 15%, Belgium 8%, West Germany 7%, Canada 5%, and other countries 27%.

Apparent consumption in the United States was about 33% of world production. Table 8 presents data on world cadmium smelter production.

During 1973, the U.S. Geological Survey published a review of world cadmium ores and resources.[2] The average ratio of zinc to cadmium in "average world zinc concentrate" is given as 230:1, but selected assays show a wide regional variation. U.S. smelters recovered cadmium as a byproduct of zinc production in the ratio of 1:229, indicating that materials fed to U.S. smelters contain slightly more cadmium than the world average and also suggesting that U.S. smelter recovery is reasonably good.

During 1973, an increase in cadmium plant capacity was announced by Texasgulf Inc., at its Timmins, Ontario, Canada, plant, and a new cadmium producing plant was started by Amax Zinc Company, Inc., at Sauget, Ill. Amax plans to gradually phase out cadmium production at the Blackwell, Okla., zinc smelter. Two large Japanese producers announced cutbacks in cadmium production because of the energy shortage.

[2] Wedow, H., Jr. Cadmium. Ch. in United States Mineral Resources. U.S. Geol. Survey Prof. Paper 820, 1973, pp. 105-109.

Table 8.—Cadmium: World smelter production [1]
(Short tons)

Country	1971	1972	1973 p
North America:			
Canada (refined)	784	1,125	e 947
United States [2]	3,965	4,145	3,714
Latin America:			
Mexico (refined)	212	205	e 220
Peru	188	231	e 260
Europe:			
Austria	28	29	e 30
Belgium	1,044	1,268	e 1,590
Bulgaria e	220	220	220
Finland	132	193	e 185
France	638	631	e 700
Germany, East e	17	17	17
Germany, West	1,081	1,007	e 1,320
Italy	386	459	e 419
Netherlands e	136	134	132
Norway	101	96	e 115
Poland e	r 440	r 390	390
Romania e	90	90	90
Spain	112	122	e 127
U.S.S.R. e	2,650	2,700	2,750
United Kingdom	289	265	346
Yugoslavia e	r 150	150	165
Africa:			
South-West Africa, Territory of	[3] 216	[4] 172	e 220
Zaire	289	326	e 331
Zambia	11	17	e 18
Asia:			
China, People's Republic of e	110	110	110
India	32	34	e 34
Japan	2,949	3,339	e 3,417
Korea, North e	120	120	120
Oceania: Australia	617	793	e 760
Total	17,007	18,388	18,747

e Estimate. p Preliminary. r Revised.

[1] Table gives unwrought metal production from ores, concentrates, flue dusts, and other materials of both domestic and imported origin. Sources generally do not indicate if secondary metal (recovery from scrap) is included; where known, this has been indicated by footnote. Data derived in part from World Metal Statistics (published by World Bureau of Metal Statistics, London) and from Metal Statistics (published by Metallgesellschaft Aktiengesellschaft, Frankfurt am Main). Cadmium is produced in ores, concentrates, and flue dusts in a number of other countries, but these materials are exported for treatment elsewhere to recover cadmium metal, therefore such output is not recorded in this table to avoid double counting.

[2] Includes secondary.

[3] Output of Tsumeb Corp. Ltd. for year ending June 30, 1971.

[4] Output of Tsumeb Corp. Ltd. for calendar year 1972.

TECHNOLOGY

During 1973, the National Environmental Research Center was reviewing the current knowledge of cadmium in the environment seeking to set standards for control consistent with the provisions of the Clean Air Act. In July, the Environmental Protection Agency (EPA) issued a list of toxic pollutants, including cadmium and cadmium compounds, in accordance with provisions of the Water Pollution Control Act. Interested parties were invited to submit comments concerning establishment of standards for effluents to meet the requirements of the Act.[3] Late in December, EPA proposed effluent standards for nine toxic pollutants, including cadmium, restricting discharges into navigable waters.[4] The daily average cadmium concentration permitted depends on the flow of the stream into which discharge is made, but shall not exceed 40 micrograms per liter in fresh water and is further restricted by a daily weight limit.

Continued interest in cadmium in the environment was shown by numerous papers

[3] Federal Register. Proposed List of Toxic Pollutants. V. 38, No. 129, July 6, 1973, pp. 18044–18045.

[4] Federal Register. Proposed Toxic Pollutant Effluent Standards. V. 38, No. 247, Dec. 27, 1973, pp. 35388–35395.

in a wide variety of scientific and engineering publications.[5]

The cadmium content of Illinois coals was investigated by the Illinois State Geological Survey; the range reported was 0.3 to 28 parts per million, with cadmium occurring as a solid solution component of sphalerite (ZnS) particles which were separated by heavy-liquid concentration from the low-temperature ash.[6]

An electrochemical process for removing cadmium, mercury, chromium, lead, and other heavy metals from waste water effluents was developed by a division of Rockwell International at Canoga Park, Calif., under the sponsorship of the State of California. Metallic impurities are plated out on a bed of fluidized conductive particles. Projected operating costs are claimed to be competitive with chemical precipitation or ion-exchange processes.[7]

Interest grew during 1973 in the development of solar energy systems using cadmium sulfide photovoltaic cells. Solar energy research programs are being conducted at the University of Delaware and several other U.S. universities as well as research centers in Japan, U.S.S.R., Israel, Australia, and other countries.[8]

A rapid method of measuring minute concentrations of cadmium was announced using an absorption spectrophotometer developed by Varian Associates, Palo Alto, Calif.[9]

A patent was granted and assigned to Bunker Hill Co. for the precipitation of cadmium from zinc sulfate solutions used in the electrolytic recovery of zinc.[10]

Conditions in a single pore of a cadmium battery plate were studied using microscopy to reveal the morphology causing loss in capacity on repeated charge and discharge.[11]

Diffusion in the silver-cadmium alloy system at 600° C was investigated to determine intrinsic diffusion coefficients and vacancy wind effects found to be appreciable in this system.[12]

Developments in cadmium technology are frequently abstracted in Zinc Abstracts, a bimonthly publication available free of charge from the Zinc Institute, Inc., 292 Madison Avenue, New York, N.Y. 10017. Numerous publications on cadmium were reviewed during 1973 describing diffusion, densities and other properties of alloys, treatment of urban and industrial effluents, the solid state physics of cadmium compounds used for semiconductors and photoconductive films, vacuum metallizing, occupational health hazards, classification for pigments, brush plating, distillation of cadmium and lead from Waelz oxides, nickel-cadmium battery components, distribution of cadmium in deep sea sediments, addition agents in cadmium plating, determination of cadmium in blood, permissible limits of metal release from glazed ceramic ware (British), corrosion resistance studies of plating and alloys, surveys of and determination of trace amounts of cadmium in

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[5] Bolton, N. E., R. I. Van Hook, W. Fulkerson, W. S. Lyon, A. W. Andren, J. A. Carter, and J. F. Emery. Trace Element Measurements at the Coal Fired Allen Steam Plant, Oak Ridge National Laboratory. ORNL–NSF–EP–43, March 1973, pp. 1–83.

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Copenhaver, E. D., G. U. Ulrikson, L. T. Newman, and W. Fulkerson. Cadmium in the Environment, an Annotated Bibliography, Oak Ridge National Laboratory. ORNL–EIS–73–17, April 1973, pp. 1–451.

Corbett, R. G., R. F. Lee, and Barbara M. Manner. Residual Effects of Cadmium Pollution, West Branch Reservoir, Ohio. Geol. Soc. of America Abstracts With Programs, v. 5, No. 5, February 1973, p. 390.

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Pita, F. W. and N. J. Hyne. Zinc, Lead and Cadmium in Reservoir Sediments. Geol. Soc. of America Abstracts With Programs, v. 5, No. 5, February 1973, p. 343.

[6] Gluskoter, H. J., and P. C. Lindahl. Cadmium: Mode of Occurrence in Illinois Coals. Science, v. 181, No. 4096, July 20, 1973, pp. 264–266.

[7] Chemical Engineering. Fluidized-Metal Traps Metal. V. 80, No. 13, June 11, 1973, p. 78.

[8] Chemical and Engineering News. Solar Energy May Achieve Wide Use by 1980's. V. 51, No. 5, Jan. 29, 1973, pp. 12–13.

[9] Chemical Week. Measuring Minute Concentrations of Cadmium. V. 113, No. 5, Aug. 1, 1973, p. 36.

[10] Orlandini, B. Precipitation of Cadmium From Zinc Sulfate Solution. U.S. Patent 3,761,251, Sept. 25, 1973.

[11] Will, F. G., and H. J. Hess. Morphology and Capacity of a Cadmium Electrode. J. Electrochem. Soc., v. 20, No. 1, January 1973, pp. 1–11.

[12] Iorio, N. R., M. A. Dayananda, and R. E. Grace. Intrinsic Diffusion and Vacancy Wind Effects in Ag-Cd Alloys. Met. Trans., v. 4, No. 5, May 1973, pp. 1339–1346.

foods, leaks in nickel-cadmium cells, and ultrafiltration compared with ion-exchange techniques for effluent processing.[13]

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[13] Zinc Institute, Inc. Zinc Abstracts. V. 31, Nos. 1–6, 1973, pp. 5–288.

Calcium and Calcium Compounds

By Avery H. Reed [1]

One company in Connecticut manufactured calcium metal. Calcium-magnesium chloride was produced by two firms in California and three in Michigan. Synthetic calcium-magnesium chloride was manufactured by four companies, in New York, Ohio, and Washington.

DOMESTIC PRODUCTION

Pfizer Inc. produced calcium metal at its Canaan, Conn., plant by the Pidgeon process, in which quicklime and aluminum powder are heated in vacuum retorts. At 1,170° C, calcium vaporizes and is collected at one end of the retort.

Leslie Salt Co. and National Chloride Co. of America produced calcium-magnesium chloride from dry lake beds in San Bernardino County, Calif. Output declined 8%. The Dow Chemical Co., Michigan Chemical Corp., and Wilkinson Chemical Corp. recovered calcium-magnesium chloride from wells in Gratiot, Lapeer, Mason, and Midland Counties, Mich. Output increased 3%.

Total production of natural calcium-magnesium chloride was 609,000 tons, 3% more than that in 1972 but 7% below the 1969 record.

Allied Chemical Corp., Syracuse, N.Y.; PPG Industries, Inc., Barberton, Ohio; and Reichold Chemicals, Inc., and Hooker Chemical Corp., Tacoma, Wash., manufactured synthetic calcium-magnesium chloride as a byproduct of soda ash. Total output decreased 23% to 249,000 tons and was 40% below the 1968 record. During the year, PPG Industries and Hooker Chemical Corp. closed their plants.

CONSUMPTION AND USES

Calcium metal was used as a reducing agent to separate such metals as columbium, tantalum, thorium, titanium, uranium, vanadium, and zirconium from their oxides; to form alloys with aluminum, lead, lithium, magnesium, and silicon; as a scavenger in the steel industry; and in the manufacture of calcium hydride.

The principal use for calcium-magnesium chloride was to melt snow and ice from roads, streets, bridges, and pavements. It was also used as a dust suppresant on roads and driveways, and as an accelerator for concrete.

[1] Physical scientist, Division of Nonmetallic Minerals—Mineral Supply.

PRICES AND SPECIFICATIONS

Calcium metal prices in 1972 ranged from $1 to $5 per pound. Calcium chloride is usually sold either as solid flake or pellet averaging about 75% $CaCl_2$, or as a concentrated liquid averaging about 40% $CaCl_2$. In 1973, on a 75% basis, average value for natural calcium chloride was $28.90; the average value for synthetic calcium chloride was $36.30.

Table 1.—Price quotations for calcium chloride

(Per short ton)

Grade	Dec. 24, 1972	Dec. 31, 1973
Flake or pellet, 94%–97% [1]	$56.50	$57.75
Flake, 77%–80% [1]	44.50	45.00
Powdered, 77% minimum [1]	52.50	53.00
Liquor, 40% [2]	17.00	17.50
Granulated, U.S.P. [3]	780.00	780.00

[1] Paper bags, carload lots, plant, freight equalized.
[2] Tank cars, freight equalized.
[3] 225-pound drums, freight equalized.

Source: Chemical Marketing Reporter. V. 204, No. 27, Dec. 31, 1973.

FOREIGN TRADE

Exports of calcium chloride in 1973, mainly to Canada, Mexico, Austria, and Brazil, totaled 889 tons valued at $117,779. Dicalcium phosphate exports, mainly to Mexico, Canada, Italy, and Brazil, were 2,447 tons valued at $369,707. Exports of precipitated calcium carbonate totaled 385 tons valued at $35,236 and were mainly to Canada, Mexico, El Salvador, and Japan.

Total imports of calcium and calcium compounds were 231,000 tons valued at $10,181,000. Imports of calcium metal from Ontario, Canada, were 55 tons valued at $77,864. Calcium chloride imports, mainly from Canada, were 7,357 tons valued at $317,007, an increase of 20% from those of 1972. Imports of other calcium compounds, mainly from Norway, the Netherlands, France, and Turkey, were 224,000 tons valued at $9,774,000.

The other calcium compounds imported included 156,113 tons of calcium nitrate from Norway, the Netherlands, Sweden, and Canada; 26,653 tons of whiting from France, the United Kingdom, Switzerland, West Germany, and Belgium; 18,216 tons of calcium borate from Turkey; 7,143 tons of calcium carbide from Canada and France; 3,893 tons of calcium cyanide from Canada, Japan, and Mexico; 3,794 tons of calcium cyanamide from Canada, Norway, West Germany, and Japan: 3,332 tons of precipitated calcium carbonate from the United Kingdom, Japan, and West Germany; 2,755 tons of dicalcium phosphate from Belgium and Canada; 530 tons of calcium hypochlorite from Japan; 140 tons of chlorinated lime from the United Kingdom and West Germany; and 1,013 tons of miscellaneous calcium compounds, mainly from Canada, Japan, and Switzerland.

Table 2.—U.S. imports for consumption of calcium and calcium chloride

Year	Calcium		Calcium chloride	
	Quantity (pounds)	Value	Quantity (short tons)	Value
1969	662,200	$619,000	9,226	$349,998
1970	164,769	141,125	8,280	359,096
1971	48,391	29,751	13,019	543,656
1972	248,080	181,437	6,128	225,463
1973	110,407	77,864	7,357	317,007

Table 3—U.S. imports for consumption of calcium chloride, by country, in 1973

Country	Quantity (short tons)	Value
Belgium-Luxembourg	212	$13,893
Canada	6,918	251,702
Germany, West	50	40,806
Japan	165	9,900
United Kingdom	12	706
Total	7,357	317,007

WORLD REVIEW

Canada.—Chromasco Corp. Ltd. produced calcium metal at its Haley smelter near Renfrew, Ontario. Canada continued to lead all other countries in the production of calcium metal; output in 1972 was 477,000 pounds valued at $342,000. Canada was the leading source of U.S. imports of calcium chloride.

France.—Planet-Wattohm S.A., a subsidiary of Compagnie de Mokta, produced calcium metal by the Pidgeon process.

TECHNOLOGY

Calcium deoxidation has given rise to a new family of more machinable steels for carburized worms and pinions. Fine-grain steels, developed by Republic Steel Corp. and sold under the trade name "Cal-DeOx" carbon and alloy gear steels, can improve cutter life 30% to 100%. Longitudinal mechanical properties and heat-treat response in annealing, and carburizing and hardening for the new steels are similar to aluminum-silicon deoxidized steel. However, Cal-DeOx steels are expected to have better transverse properties and fatigue resistance. One gear and axle plant already has increased productivity 25% by switching to the new steels.[2]

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[2] Materials Engineering. Calcium Deoxidized Steels Improve Gear Cutting. V. 77, No. 7, May 1973, pp. 48–50.

Carbon Black

By John L. Albright [1]

Carbon black production and shipments increased during 1973, continuing the trend of the last 3 years. Domestic sales reached 3,314 million pounds, more than double the sales of 20 years earlier. Producers' stocks declined below the 1972 level. Texas produced more carbon black than any other State, and Louisiana maintained its position as the country's second largest producer. Total production was 3,500 million pounds. Increased furnace black production more than offset declines in channel black, and total production recorded a 9.3% increase over the 1972 output. Overall demand continued to increase, although channel black, Intermediate-Abrasion Furnace (ISAF) and Superabrasion Furnace (SAF) production and shipments decreased during 1973.

Shipments totaled 3,507 million pounds, including 192.7 million pounds exported. Domestic shipments increased for the third consecutive year and totaled 3,315 million pounds, surpassing the previous year's shipments by 5.3%. Exports, ending a 4-year downward trend, increased 81 million pounds over the 1972 low and totaled 193 million pounds in 1973. Imported carbon black and bone black totaled 8.7 million pounds and was supplied mainly by Canada, Indonesia, and West Germany.

Numerous industries utilized carbon black, but the largest volumes were consumed by ink, paint, plastic, and rubber products manufacturers. The rubber industry continued to be the largest consumer, and most carbon black went into the manufacture of highway vehicle tires and tubes. According to the Rubber Manufacturers Association, Inc., 189.2 million motorcycle and passenger tires were produced in 1973, a decrease of 3.3% from the previous year; bus and truck tire production reached a record 34.3 million units, up 0.8% from that of 1972. Combined tire shipments during the year totaled 238.9 million units, including exports.

Carbon black producing plants operated at 82.9% capacity in 1973, the highest rate reported since 1968, and plant capacity increased 1.4% during 1973. Daily plant capacity has grown 4.5 million pounds during the last 10 years. More than three-fourths of the carbon black plant capacity is in Louisiana and Texas.

Average value of carbon black produced was 8.12 cents per pound in 1973, an increase of 0.36 cent per pound over the 1972 average. Recent annual average values had not exceeded 8 cents per pound. Carbon black production from liquid hydrocarbons and natural gas, with nearly 93% of the production from liquid hydrocarbons feedstocks, was up 1.4% from 1972 and 3.6% from 1971. Natural gas feedstock continued its downward trend; the volume of natural gas used declined 4,257 million cubic feet. Yield from natural gas declined 24.6 million pounds, from 5.02 pounds per thousand cubic feet in 1972 to 4.96 pounds per thousand cubic feet in 1973. More than 32 million additional gallons of liquid hydrocarbon feedstocks were utilized, and average yield of carbon black from this feedstock increased from 4.96 to 5.22 pounds per gallon.

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[1] Mineral specialist, Division of Fossil Fuels—Mineral Supply.

Table 1.—Salient statistics of carbon black produced from natural gas and liquid hydrocarbons in the United States

(Thousand pounds)

	1969	1970	1971	1972	1973
Production:					
Channel process	132,471	113,548	46,354	22,378	14,222
Furnace process	2,830,790	2,817,605	2,970,781	3,178,731	3,485,719
Total	2,963,261	2,931,153	3,017,135	3,201,109	3,499,941
Shipments (including losses):					
Domestic	2,783,208	2,650,450	2,853,948	3,148,114	3,314,646
Exports	196,203	192,636	163,246	111,328	192,665
Total	2,979,411	2,843,086	3,017,194	3,259,442	3,507,311
Producer stocks Dec. 31	208,020	296,087	296,028	237,695	230,325
Value:					
Production thousand dollars	215,120	222,271	232,049	248,361	284,153
Average per pound cents	7.26	7.58	7.69	7.76	8.12

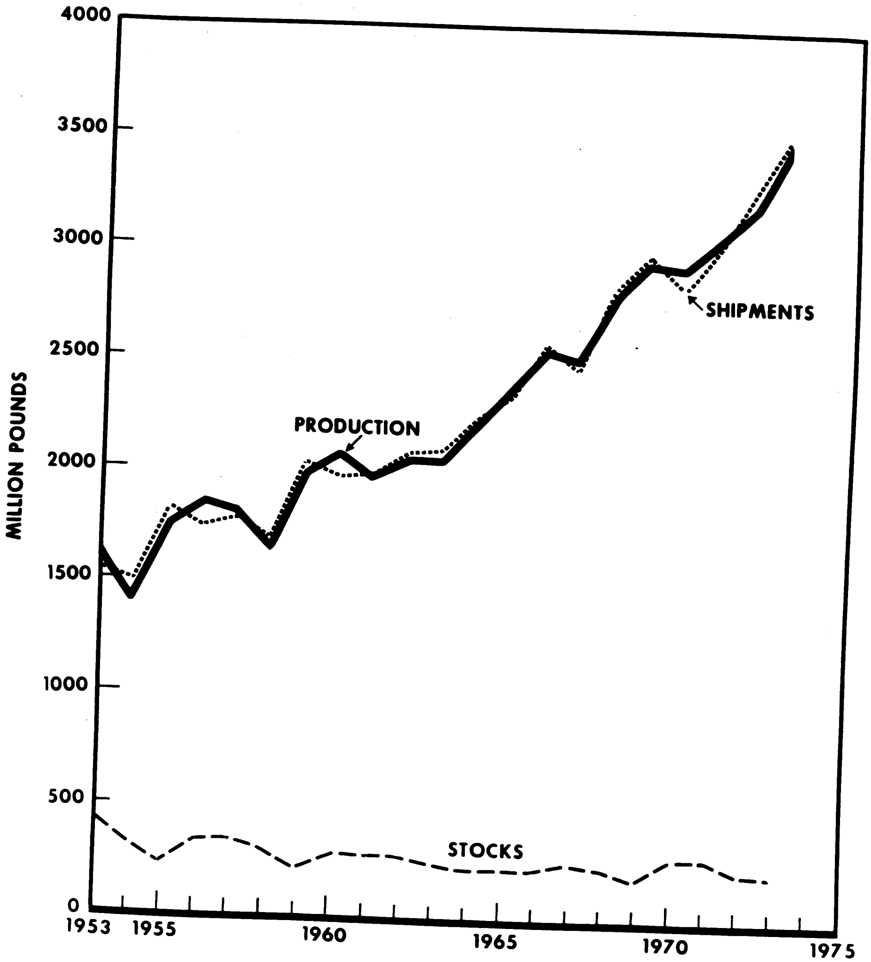

Figure 1.—Production, stocks, and shipments of carbon black.

PRODUCTION AND CAPACITY

Production by State.—In 1973, carbon black production totaled 3,500 million pounds, an increase of 299 million pounds over the previous year's total. Louisiana and Texas plants produced an aggregate of 2,719 million pounds, 77.7% of the national total. The remaining carbon black production came from plants in Alabama, Arkansas, California, Kansas, Ohio, Oklahoma, and West Virginia.

Production by Grade and Type.—Seven major grades of carbon black, produced by the furnace combustion and thermal cracking methods, comprised 99.6% of the 1973 production. The remainder was produced by the channel black process, which continued its long-term diminishing pattern. Channel black production was 14 million pounds in 1973, down 36.5% from the previous year. The combined production of General-Purpose Furnace (GPF) and High-Abrasion Furnace (HAF) grades accounted for 60.5% of the furnace blacks produced. Semireinforcing Furnace (SRF) was the major grade of carbon black produced by the gas furnace process.

Number and Capacity of Plants.—Thirty-four carbon black plants continued to operate in the United States, unchanged from the previous year, and more than three-fourths of the installed plant capacity was in Louisiana and Texas. Although no new plants were constructed, capacities of existing plants were increased during the year. Cabot Corp. introduced new technology furnace blacks in 1973 to replace many of the darkest color channel blacks for specialty applications. The corporation announced plans to shut down its last channel black plant during 1974. Cabot's new product, Large-Particle Furnace (LPF), was developed as a replacement for regular thermal black. Significant capital expenditures were made by Cabot during 1973 for modernization of the Ville Platte, La., plant and for expansions at the Franklin, La., installation. During 1973 Cabot added approximately 120 million pounds per year of furnace black plant capacity and reduced the capacity of thermal black by approximately 30 million pounds per year.

J. M. Huber Corp. continued expanding its Texas carbon black plants. A second thermal black unit was completed during 1973, at Borger, increasing the company's annual thermal capacity to 42 million pounds. Other improvements underway at the Baytown and Borger, Tex., facilities were scheduled for completion in mid-1974. At that time, the company's annual capacity of oil furnace blacks will be 333 million pounds, and the gas furnace black annual capacity will be 36 million pounds.

Phillips Petroleum Co. added 20 million pounds per year capacity to its Borger, Tex., carbon black plant. A further 47 million pounds of yearly capacity was authorized to be added to Phillip's Texas facilities, 27 million pounds at Borger and the remainder at Orange.

Materials Used and Yields.—In 1973, a total of 623.2 million gallons of liquid hydrocarbons was consumed in the manufacture of 3,254 million pounds of carbon black. There was 32 million gallons more of liquid hydrocarbons consumed in 1973 than in 1972. Yields averaged 5.22 pounds per gallon from liquid hydrocarbons, compared with 4.96 pounds per gallon in 1972. Natural gas feedstock decreased 4,257 million cubic feet to 49,682 million cubic feet, and the volume of carbon black produced from natural gas was 246 million pounds, a decline of 24.6 million pounds from the 1972 production. Yields from natural gas in 1973 averaged 4.96 pounds of carbon black per thousand cubic feet, a decrease of 1.2% from that of the previous year.

CONSUMPTION AND USES

Over 90% of the carbon black consumption was in rubber applications, and the rubber tire industry was the principal consumer. Carbon black is an essential ingredient in the manufacture of tires. Passenger car tires use 6 to 7 pounds of carbon black each, and average truck tires contain approximately 20 pounds of blacks. Domestic sales of carbon black increased in 1973 by 166.9 million pounds, or 5.3%. Aggregate sales enjoyed the third consecutive year of growth, as records were established in all major consuming sectors, except the paper industry. Sales for use in the manufacture of ink increased 1.8 million pounds and those to the rubber industry increased to 3,115 million pounds in 1973.

STOCKS

Yearend 1973 carbon black stocks were 230.3 million pounds, down 7.4 million pounds from the yearend 1972 inventory. Channel black stocks declined significantly from 7.7 million pounds to 2.4 million pounds, and furnace black inventories were 2.0 million pounds below the yearend 1972 level. Yearend 1973 stocks of GPF, HAF, and SRF grades of furnace blacks were slightly higher than stocks available at the end of 1972, but this increase was offset by reduced stocks of thermal, Fast-Extrusion Furnace (FEF), ISAF, and SAF grades of carbon blacks.

FOREIGN TRADE

Carbon black exports totaled 192.7 million pounds, an increase of 81.4 million pounds over the 1972 total, and was the largest volume exported since 1969. Channel black accounted for less than 8% of the quantity exported but 31% of the $24.1 million total value of exported carbon blacks. Average value of channel black exported in 1973 was 49.9 cents per pound, (46.3 cents per pound in 1972) and that of furnace black was 9.3 cents per pound (9.4 cents per pound in 1972).

The Netherlands, Canada, and Brazil purchased the largest consignments of U.S. produced carbon black, followed by France, Taiwan, and Japan. These six countries accounted for more than 63% of U.S. exports. Carbon black imported during 1973 amounted to 8.7 million pounds plus 230 thousand pounds of bone black. This represented an impressive increase from the 1972 carbon black imports, but imported blacks accounted for only 0.2% of total supplies. More than 96% of the imported material originated in Canada, Indonesia, and West Germany. In 1973, imported carbon black was valued at an average 11.4 cents per pound compared with the average value of 12.5 cents per pound for exported carbon blacks; the 1972 values were 15.3 and 13.4 cents per pound respectively.

WORLD REVIEW

More than three-fourths of the known worldwide carbon black production was from Western European and North American plants. North America accounted for nearly half of the 1973 world production of carbon black. The Republic of South Africa was the only producer in Africa. Production information was sparse for Communist countries. The United States, Japan, and West Germany were the three largest producers, as shown in table 11.

In 1973, world demand was strong for carbon black, and plants operated at near capacity. Increased shipments were recorded by carbon black producers in most countries, as 1973 sales surpassed previous levels, and production and bulk storage installations were expanded to meet increasing demand. In Canada, Cancarb Ltd. completed the construction of the Medicine Hat, Alberta, thermal carbon black plant, with an initial capacity of 40 million pounds annually of pelletized medium thermal black.

New carbon black plants were inaugurated in Asia and the Middle East. Plans were finalized for a 25-million-pound-per-year plant to be built by Australian Carbon Black Pty., Ltd. (ACB) near Port Dickson, Malaysia. Malaysian Government and private groups will hold 50% ownership in the new plant, and ACB will hold the remaining stock and will operate the facility. Iran Carbon Co.'s carbon black plant, the first in the Middle East, was under construction during 1973 at Akwaz, Iran. It is scheduled to begin production in 1974. Initially, the plant will have an annual capacity of 33 million pounds and will market most of its products domestically. After 4 years of operation, the Iranian plant's capacity is to be doubled, and exports will commence to consumers along the Indian Ocean, the Persian Gulf, and the Red Sea.

Cities Service Co. and Phillips Petroleum Co. acquired 50% interest each in the Sevalco Ltd. (formerly Philblack Ltd.), Bristol, England, carbon black plant. The Bristol facility had an annual capacity of 251 million pounds. During 1973 Continental Carbon Co. sold a license to a Taiwan firm to use its patent rights and technical knowledge in the manufacture of carbon black in that country.

TECHNOLOGY

Carbon black, a petrochemical, is an extremely fine soot, primarily carbon (90% to 99%), that contains some hydrogen and oxygen. Oil furnace black may also contain small amounts of sulfur. Properties of carbon black are determined largely by the process by which it is manufactured. Furnace black, which accounts for 99% of all carbon black produced, is made by three different processes—gas furnace, oil furnace, and thermal. Brief descriptions follow of these processes, the channel process, and the manufacture of lampblack and acetylene black.

Gas Furnace.—The gas furnace process is based on partial combustion of natural gas in refractory-lined furnaces. Carbon black is removed by flocculation and high-voltage electric precipitators. Yields of the gas furnace blacks range from 10% to 30% and are lowest for the smaller particle-size grades. Properties of gas furnace blacks can be modified to a degree by changing the ratio of air to gas. High-Modulus Furnace (HMF) and SRF grades are generally produced from gas.

Oil Furnace.—Liquid hydrocarbons are used in the oil furnace process. Natural gas is generally burned to furnish the heat of combustion, and atomized oil is introduced into the combustion zone to be burned to various grades of carbon black. Yields range from 35% to 65%, depending on the grade of black produced. Oil furnace grades are FEF, GPF, HAF, ISAF, and SAF.

The most desirable feedstock oil for furnace black plants has 0° to 4° API gravity, is low in sulfur, and is high in aromatics and olefins. It comes from near the "bottom of the refinery barrel" and is similar in many respects to residual fuel oil. Rising costs of natural gas have been a factor in the shift to greater use of liquid feedstocks and a decline in the use of natural gas as a source of carbon. Oil furnace processing has become highly flexible, supplementing channel blacks in most high-performance applications, notably passenger car tires. Over the past 2 decades, carbon black technology has centered on the oil furnace black process.

Thermal.—Unlike channel and furnace blacks, thermal blacks are produced by cracking hydrocarbons; that is, by separating carbon from the hydrogen and not by the combustion of hydrocarbons. Thermal furnaces are built in a checkerboard brickwork pattern. Two refractory-lined furnaces, or generators, are used. One generator is heated using hydrogen as a fuel, while the other generator is charged with natural gas, which decomposes to produce thermal black and hydrogen. Hydrogen collected is used as fuel for the generator being heated. Yields of carbon black are primarily in the large particle sizes and range from 40% to 50%.

Channel Black.—Made by the oldest process, channel black is a product of incomplete combustion of natural gas. Small flames are impinged on cool surfaces, or channels, where carbon black is deposited and then scraped off as the channel moves back and forth over a scraper. Properties of channel black are varied by changes in burner tip design, distances from tip to channel, and the amount of air made available for combustion. The process is extraordinarily inefficient chemically. For rubber-reinforcing grades, the yield is only 5%; for high-color blacks of finer particle sizes, the yield shrinks to 1%. Low yields and rising gas prices have spurred the industry to develop other methods to make blacks.

Lampblacks.—Lampblacks are manufactured by slowly burning selected oils and tars in a restricted supply of air. These blacks are of large particle size, possess little reinforcing ability in rubber, and are low in jetness and coloring power. They are of value as tinting pigments in certain paints and lacquers. In most applications lampblacks have been replaced by carbon blacks.

Acetylene Black.—Acetylene blacks, produced by the thermal decomposition of acetylene, possess a high structural, or chaining, tendency. Their particle size is about 40 millimicrons. They provide high elastic modulus and high conductivity in rubber stocks.

Coal-derived carbon blacks have yet to be produced commercially, but several small companies are marketing carbon black extenders and fillers which are produced from anthracite and bituminous coals. These carbon black substitutes are used in rubber compounding and in the production of carbon paper, ink, paint, and plastic. Extenders-fillers from coal are being utilized in conjunction with furnace carbon blacks, replacing thermal carbon blacks.

Table 2.—Carbon black produced from natural gas and liquid hydrocarbons in the United States, by State

(Thousand pounds)

	1969	1970	1971	1972	1973	Change from 1972 (percent)
Louisiana	1,045,902	982,416	1,078,732	1,077,977	1,207,708	+12.0
Texas	1,442,033	1,395,851	1,326,153	1,425,874	1,511,127	+ 6.0
Other States	475,326	552,886	612,250	697,258	781,106	+12.0
Total	2,963,261	2,931,153	3,017,135	3,201,109	3,499,941	+ 9.3

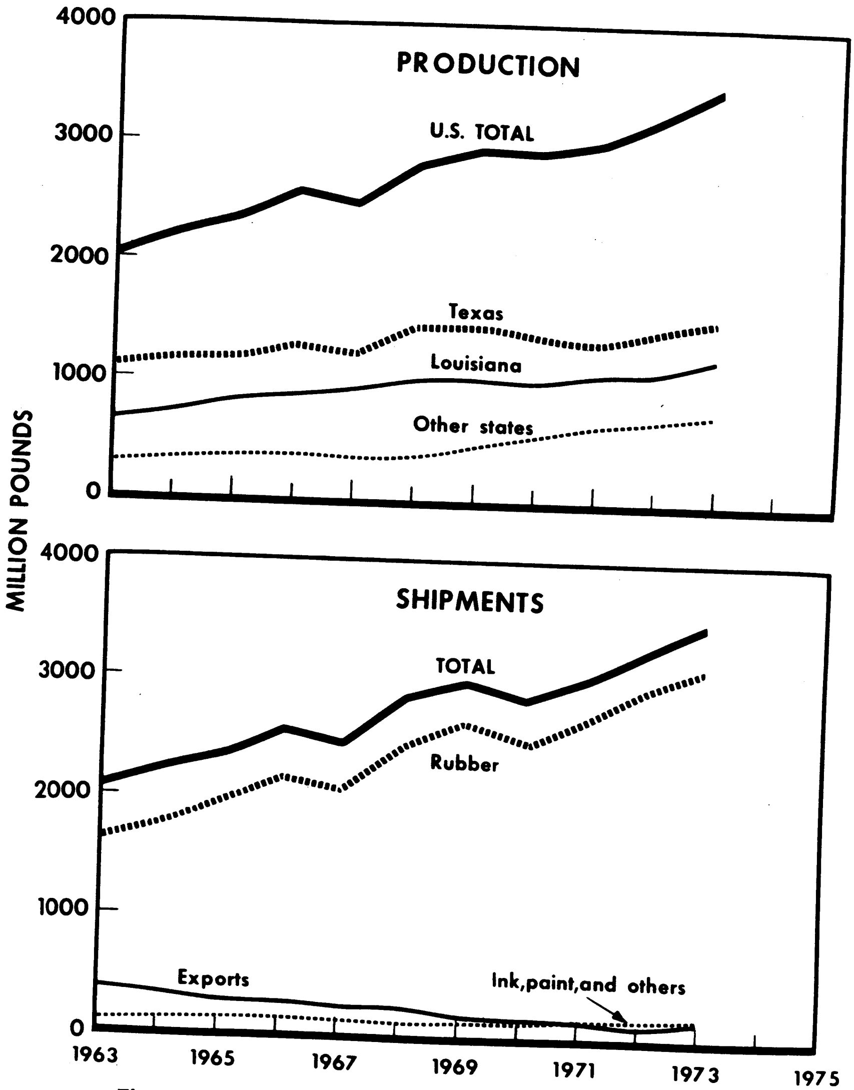

Figure 2.—Production by State, shipments by use, and exports.

Table 3.—Production and shipments of carbon black in the United States in 1973, by month and grade

(Thousand pounds)

	SRF [1]	GPF [2]	FEF [3]	HAF [4]	SAF [5]	ISAF [6]	Thermal	Total Furnace	Channel	Total
PRODUCTION [7]										
January	24,692	56,842	27,610	104,355	3,432	32,419	24,270	273,620	1,105	274,725
February	23,265	58,278	33,244	102,330	2,742	27,485	22,758	270,102	1,259	271,361
March	28,767	64,598	34,335	126,226	2,169	30,961	28,281	315,337	1,500	316,837
April	29,504	58,892	38,391	118,668	2,756	30,576	25,582	304,369	1,355	305,724
May	31,189	56,766	37,175	124,759	3,510	26,521	29,090	309,010	1,348	310,358
June	31,170	54,317	31,181	108,888	3,701	26,390	24,879	280,526	1,218	281,744
July	27,176	46,766	31,352	100,995	1,888	26,830	25,220	260,227	1,217	261,444
August	23,551	48,061	30,817	113,374	3,427	21,260	26,934	267,424	1,285	268,709
September	25,446	61,052	27,027	118,652	2,602	20,458	27,273	282,510	1,207	283,717
October	26,016	61,726	33,787	130,409	3,222	23,322	30,202	308,684	1,185	309,869
November	28,429	59,897	36,017	128,649	2,579	19,664	25,549	300,784	691	301,475
December	27,241	66,663	31,380	136,294	2,323	22,744	26,481	313,126	852	313,978
Total	326,446	693,858	392,316	1,413,599	34,351	308,630	316,519	3,485,719	14,222	3,499,941
SHIPMENTS (including exports) [8]										
January	26,827	64,268	37,293	115,601	4,207	32,908	27,753	308,857	1,462	310,319
February	26,398	58,753	34,552	109,801	2,787	32,300	23,457	288,048	1,425	289,473
March	30,729	64,861	38,220	127,020	3,115	32,402	29,121	325,468	1,931	327,399
April	29,733	57,689	37,001	116,498	3,152	29,130	25,195	298,398	1,657	300,055
May	26,810	52,018	35,628	120,222	3,048	28,769	28,018	294,513	2,186	296,699
June	25,210	46,610	27,898	95,768	3,426	23,712	26,283	248,907	1,661	250,568
July	23,789	46,931	27,550	97,324	2,580	24,781	25,726	248,681	1,384	250,065
August	27,972	54,364	32,608	115,369	2,382	22,343	27,280	282,318	1,453	283,771
September	23,506	53,953	27,187	114,510	2,739	22,509	26,802	271,206	1,677	272,883
October	28,982	67,623	37,204	138,105	3,357	26,070	28,031	329,372	1,807	331,179
November	28,937	61,789	34,907	131,028	2,811	23,681	27,079	310,232	1,579	311,811
December	24,647	56,234	30,426	123,736	2,633	20,997	23,089	281,762	1,327	283,089
Total	323,540	685,093	400,474	1,404,982	36,237	319,602	317,834	3,487,762	19,549	3,507,311

[1] Semireinforcing furnace.
[2] General-purpose furnace (includes High-modulus furnace).
[3] Fast-extrusion furnace.
[4] High-abrasion furnace.
[5] Superabrasion furnace.
[6] Intermediate-abrasion furnace.
[7] Compiled from reports of a survey firm and producing companies. Figures adjusted to agree with annual reports of individual producers.
[8] Includes losses.

Table 4.—Number and capacity of carbon black plants operated in the United States

State	County or Parish	Number of plants 1972 Channel	1972 Furnace	1973 Channel	1973 Furnace	Total daily capacity (pounds) 1972	1973
Texas	Aransas	--	1	--	1	5,075,602	5,213,511
	Carson	1	--	1	--		
	Gaines	1	--	1	--		
	Gray	--	1	--	1		
	Harris	--	1	--	1		
	Howard	--	2	--	2		
	Hutchinson	--	2	--	2		
	Montgomery	--	1	--	1		
	Moore	--	1	--	1		
	Orange	--	1	--	1		
	Terry	--	1	--	1		
	Wheeler	--	1	--	1		
Total Texas		2	12	2	12	5,075,602	5,213,511
Louisiana	Avoyelles	--	1	--	1	3,870,108	3,851,837
	Calcasieu	--	1	--	1		
	Evangeline	--	1	--	1		
	Ouachita	--	2	--	2		
	St. Mary	--	3	--	3		
	West Baton Rouge	--	1	--	1		
Total Louisiana		--	9	--	9	3,870,108	3,851,837
Alabama	Russell	--	1	--	1	2,465,849	2,507,833
Arkansas	Union	--	1	--	1		
California	Kern	--	3	--	3		
Kansas	Grant	--	1	--	1		
Ohio	Lucas	--	1	--	1		
	Washington	--	1	--	1		
Oklahoma	Kay	--	1	--	1		
West Virginia	Pleasants	--	1	--	1		
	Marshall	--	1	--	1		
Total other States		--	11	--	11	2,465,849	2,507,833
Total United States		2	32	2	32	11,411,559	11,573,181

Table 5.—Carbon black and feedstock used in its production, by State

	Louisiana	Texas	Other States[1]	Total
1972				
Carbon black production:				
Total ---thousand pounds--	1,077,977	1,425,874	697,258	3,201,109
Value ---thousand dollars--	78,843	117,963	51,555	248,361
Average value ---cents per pound--	7.31	8.27	7.39	7.76
Natural gas used:[2]				
Total ---million cubic feet--	23,563	24,720	5,656	53,939
Value ---thousand dollars--	4,721	4,356	1,460	10,537
Average value cents per thousand cubic feet--	20.04	17.62	25.81	19.54
Carbon black produced[3] thousand pounds--	207,575	43,219	20,182	270,976
Liquid hydrocarbons used:				
Total ---thousand gallons--	177,633	277,642	135,478	590,753
Value ---thousand dollars--	14,051	22,572	11,405	48,028
Average value ---cents per gallon--	7.91	8.13	8.41	8.13
Carbon black produced--thousand pounds--	870,402	1,382,655	677,076	2,930,133
1973				
Carbon black production:				
Total ---thousand pounds--	1,207,708	1,511,127	781,106	3,499,941
Value ---thousand dollars--	96,824	128,144	59,185	284,153
Average value ---cents per pound--	8.02	8.48	7.58	8.12
Natural gas used:[2]				
Total ---million cubic feet--	21,278	23,142	5,262	49,682
Value ---thousand dollars--	5,181	5,236	1,601	12,018
Average value cents per thousand cubic feet--	24.35	22.63	30.43	24.19
Carbon black produced[3] thousand pounds--	182,107	42,878	21,438	246,423
Liquid hydrocarbons used:				
Total ---thousand gallons--	186,577	295,358	141,301	623,236
Value ---thousand dollars--	16,149	25,989	14,158	56,296
Average value ---cents per gallon--	8.66	8.80	10.02	9.03
Carbon black produced-thousand pounds--	1,025,601	1,468,249	759,668	3,253,518

[1] Arkansas, California, Kansas, Ohio, Oklahoma, and West Virginia.
[2] Includes natural gas used to enrich liquid hydrocarbons.
[3] Produced from natural gas used as feedstock.

Table 6.—Natural gas and liquid hydrocarbons used in manufacturing carbon black in the United States and average yield

	1969	1970	1971	1972	1973
Natural gas used[1] ---million cubic feet--	98,251	85,884	63,699	53,939	49,682
Average yield of carbon black per thousand cubic feet ---pounds--	4.64	4.44	5.06	5.02	4.96
Average value of natural gas used per thousand cubic feet ---cents--	14.88	16.45	17.51	19.54	24.19
Liquid hydrocarbons used ---thousand gallons--	524,370	523,914	547,704	590,753	623,236
Average yield of carbon black per gallon pounds--	4.78	4.87	4.92	4.96	5.22
Average value of liquid hydrocarbons used per gallon ---cents--	7.23	7.35	7.96	8.13	9.03
Number of producers reporting ---	9	9	9	8	8
Number of plants ---	38	37	37	34	34

[1] Includes natural gas used to enrich liquid hydrocarbons.

Table 7.—Sales of carbon black for domestic consumption in the United States, by use

(Thousand pounds)

Use	1969	1970	1971	1972	1973	Change from 1972 (percent)
Ink	73,077	72,824	75,201	82,532	84,364	+2.22
Paint	17,711	14,570	18,693	21,408	21,667	+1.21
Paper	5,668	4,527	3,767	4,225	4,212	−0.31
Rubber	2,616,166	2,486,146	2,678,151	2,953,779	3,114,565	+5.44
Miscellaneous [1]	65,327	71,454	77,715	84,764	88,786	+4.74
Total	2,777,949	2,649,521	2,853,527	3,146,708	3,313,594	+5.30

[1] Includes chemical, food, plastics, and metallurgical.

Table 8.—Producers' stocks of channel and furnace-type blacks in the United States, December 31

(Thousand pounds)

Year	Furnace									Channel	Total
	SRF	HMF	GPF	FEF	HAF	SAF	ISAF	Thermal	Total		
1969	24,478	2,518	20,082	22,254	48,725	4,734	38,712	28,044	189,547	18,473	208,020
1970	37,875	2,048	46,930	24,771	64,106	5,666	50,513	42,119	274,028	22,059	296,087
1971	33,551	3,158	35,885	27,619	68,798	6,417	42,870	67,987	286,285	9,743	296,028
1972	24,309	([1])	33,351	27,817	83,446	7,437	36,558	17,100	230,018	7,677	237,695
1973	27,215	([1])	42,116	19,659	92,063	5,551	25,586	15,785	227,975	2,350	230,325

[1] Included with GPF.

Table 9.—U.S. exports of carbon black, by country

(Thousand pounds and thousand dollars)

Country	1971		1972		1973	
	Quantity	Value	Quantity	Value	Quantity	Value
North America:						
Canada	26,736	2,472	19,735	2,057	26,226	1,942
Guatemala	396	42	148	17	1,549	161
Jamaica	848	73	23	3	1,391	148
Mexico	2,080	247	1,662	273	4,303	342
Other	447	48	515	49	401	48
Total	30,507	2,882	22,083	2,399	33,870	2,641
South America:						
Argentina	3,412	433	1,425	248	1,553	198
Brazil	6,423	689	3,553	385	24,074	2,178
Chile	433	69	318	54	446	61
Colombia	529	97	471	77	543	79
Peru	192	27	250	29	276	40
Venezuela	941	100	809	97	670	74
Other	183	24	55	9	188	21
Total	12,113	1,439	6,881	899	27,750	2,651
Europe:						
Austria	81	21	140	43	145	17
Belgium-Luxembourg	2,143	233	2,931	278	1,900	242
Denmark	823	130	954	180	596	125
Finland	163	27	302	33	227	128
France	16,514	1,900	13,815	1,558	14,444	1,661
Germany, West	6,997	878	7,252	792	9,380	929
Italy	5,894	830	4,212	552	4,142	735
Netherlands	43,622	5,550	r 15,898	r 2,434	30,436	5,179
Norway	874	82	433	42	281	27
Portugal	253	39	278	43	500	63
Romania	--	--	--	--	522	87
Spain	2,295	274	1,961	261	2,741	347
Sweden	1,006	89	192	24	438	34
Switzerland	986	93	955	103	724	93
United Kingdom	6,416	989	r 5,535	r 904	9,411	1,335
Yugoslavia	99	26	148	42	328	75
Other	168	25	71	14	14	3
Total	88,334	11,186	r 55,077	r 7,303	76,229	11,080
Africa:						
Angola	13	3	1	1	73	7
Ghana	1,089	100	940	115	2,262	244
Kenya	631	56	748	67	1,173	98
South Africa, Republic of	5,939	600	4,431	424	5,148	624
Tanzania	168	16	51	6	350	35
Other	112	12	55	7	136	27
Total	7,952	787	6,226	620	9,142	1,035
Asia:						
Cambodia	--	--	115	10	110	11
Hong Kong	306	42	202	34	371	58
India	912	146	1,988	233	619	97
Indonesia	185	15	195	16	252	28
Iran	573	50	91	15	55	15
Israel	324	38	468	51	431	59
Japan	8,828	2,335	7,996	2,117	13,706	3,165
Korea, Republic of	480	95	532	120	4,019	486
Lebanon	119	11	118	11	136	11
Malaysia	136	11	246	19	155	23
Pakistan	209	18	226	18	3,123	278
Philippines	637	72	625	59	1,211	139
Singapore	197	28	294	32	277	56
South Vietnam	725	88	1,071	93	1,340	160
Taiwan	796	196	748	159	14,110	1,381
Thailand	1,050	92	634	58	356	43
Turkey	687	66	100	14	164	34
Other	2	6	19	3	16	2
Total	16,166	3,309	15,668	3,062	40,451	6,046
Oceania:						
Australia	6,074	635	3,523	407	3,429	411
New Zealand	2,100	187	1,780	166	1,794	192
Total	8,174	822	5,303	573	5,223	603
Grand total	163,246	20,425	r 111,238	r 14,856	192,665	24,056

r Revised.

Table 10.—U.S. exports of carbon black in 1973, by month

(Thousand pounds and thousand dollars)

Month	Channel		Furnace		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
January	690	414	8,244	918	8,934	1,332
February	2,492	633	8,517	876	11,009	1,509
March	1,648	708	10,139	1,067	11,787	1,775
April	1,231	650	13,323	1,356	14,554	2,006
May	1,700	1,063	14,060	1,576	15,760	2,639
June	1,110	473	11,488	1,296	12,598	1,769
July	730	373	18,741	1,067	19,471	1,440
August	1,110	765	14,372	1,692	15,482	2,457
September	734	519	22,730	1,623	23,464	2,142
October	990	666	22,747	2,131	23,737	2,797
November	1,143	450	16,109	1,431	17,252	1,881
December	1,362	738	17,255	1,571	18,617	2,309
Total	14,940	7,452	177,725	16,604	192,665	24,056

Table 11.—Carbon black: World production by country

(Million pounds)

Country[1]	1971	1972	1973[p]
Argentina[e]	66	66	66
Australia[e]	116	128	131
Belgium[e]	4	4	4
Brazil	126	[e] 132	[e] 143
Canada[e]	186	196	258
Colombia[e]	40	45	50
Czechoslovakia[e]	22	33	33
France	345	350	[e] 353
Germany, West	578	582	641
Hungary[e]	9	9	10
India	84	[e] 88	[e] 100
Indonesia	1	[e] 3	[e] 3
Italy	276	288	[e] 320
Japan	679	751	891
Korea, Republic of	[r] 17	19	29
Mexico[e]	70	74	74
Netherlands	204	206	[e] 209
Romania	[r] 165	163	[e] 163
South Africa, Republic of[e]	62	66	66
Spain	[r] 110	[e] [r] 110	111
Sweden[e]	45	50	54
Taiwan	(2)	(2)	[e] (2)
United Kingdom	480	450	[e] 463
United States	3,017	3,201	3,500
Venezuela[e]	16	16	18
Yugoslavia	35	29	[e] 31
Total	[r] 6,753	7,059	7,721

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition to the countries listed, the People's Republic of China, Norway, Poland, Turkey and the U.S.S.R. produce carbon black, but available information is inadequate to make reliable estimates of production levels.

[2] Less than ½ unit.

Cement

By Robert E. Ela [1]

Portland cement shipments from plants in the United States and Puerto Rico continued at record levels for the third consecutive year to attain a new high of 86,399,000 tons in 1973, surpassing the 1972 record by 6%. Mill value rose to $1.89 billion, an increase of 15%, reflecting a unit increase of $1.57 per ton.

The supply and demand relationship changed dramatically in many parts of the country. Contributing factors were curtailed production due to previous closings of older and uneconomical plants, minor fuel shortages, shifting markets, labor disputes, severe weather conditions, and spring floods. The construction industry which represents virtually the entire market for the cement industry reached an historical milestone in 1973 when over $100 billion in contracts were awarded.

During the year increased volume in industrial, commercial, and government construction projects, such as mass transit, more than offset a decline in residential and highway construction. Housing starts declined because of increased lumber prices, labor costs, and high interest rates.

The cement industry, which only recently became highly dependent on oil and natural gas for its fuel requirements, was now returning to coal as a means of assuring uninterrupted production. Many companies were initiating plans to secure adequate supplies of fuel for existing systems.

Two companies changed corporate names. American Cement Corp. was changed to Amcord, Inc., and Penn Dixie Cement Corp. was changed to Penn Dixie Industries. Columbia Cement Company Division of PPG Industries, Inc., was sold to Filtrol Corp. in mid-1973. The sale involved the plants at Bellingham, Wash., and Zanesville, Ohio, and all distribution facilities. The cement plant at Barberton, Ohio, was not included in the sale and continued to operate as a unit of the Chemical Division of PPG Industries, Inc.

Statistical data in some of the tabulations are arranged by cement districts. A cement district represents either a State, a segment

[1] Statistical specialist, Division of Nonmetallic Minerals—Mineral Supply.

Table 1.—Salient cement statistics

(Thousand short tons and thousand dollars)

	1969	1970	1971	1972	1973
United States: [1]					
Production [2]	76,693	74,325	78,324	82,597	85,438
Shipments from mills [2 3]	78,637	74,607	80,396	83,336	88,467
Value [2 3 4]	$1,354,033	$1,336,255	$1,528,056	$1,724,140	$1,970,602
Average value per ton [2]	$17.22	$17.91	$19.01	$20.69	$22.27
Stocks Dec. 31 at mills [5]	7,129	7,574	r 6,425	r 7,036	5,511
Exports r	67	123	84	83	268
Imports for consumption r	1,708	2,473	3,057	4,851	6,644
Consumption, apparent r 6 7	80,279	75,882	81,498	84,952	90,479
World: Production	598,825	629,645	r 679,948	r 728,601	780,344

r Revised.
[1] Excludes Puerto Rico.
[2] Includes portland, masonry, and slag cement (1969). Excludes slag cement (1970–73).
[3] Includes imported cement shipped by domestic producers only.
[4] Value received, f.o.b. mill, excluding cost of containers.
[5] Includes portland, masonry (1970–73), slag cement (1969).
[6] Quantity shipped plus imports minus exports.
[7] Adjusted to eliminate duplication of import (clinker and cement) shipped by domestic cement manufacturers.

of a State, or a group of States not necessarily contiguous. The States of California, New York, and Pennsylvania are further divided to provide additional marketing information. The divisions for these States are as follows:

California, Northern.—Points north and west of the northern borders of San Luis Obispo and Kern Counties and the western borders of Inyo and Mono Counties.

California, Southern.—All other counties in California.

New York, Western.—All counties west of a dividing line following the eastern boundaries of St. Lawrence, Lewis, Oneida, Madison, Chenango, and Broome Counties.

New York, Eastern.—All counties east of the above dividing line.

New York, Metropolitan.—The five counties of New York City, (Bronx, Kings, New York, Queens, and Richmond) plus Westchester, Rockland, Suffolk, and Nassau Counties.

Pennsylvania, Eastern.—All counties east of the eastern boundaries of Potter, Clinton, Centre, Huntingdon, and Franklin Counties.

Pennsylvania, Western.—All other counties in Pennsylvania.

Legislation and Government Programs.—On November 27 the Cost of Living Council (CLC) exempted from price and wage controls (under the Economic Stabilization Program) manufacturers' sales of cement and wages paid to workers in the cement industry. The exemption from price controls applied to cements listed in Part 9 of the 1973 Annual Book of ASTM Standards as follows: C–150 (portland cement); C–10 (natural cement); C–91 (masonry cement); C–595 (blended hydraulic cements); and expansive, calcium aluminate, oil well, plastic, and regulated-set cements. The CLC received commitments that production capacity would be increased expeditiously to alleviate developing supply problems.

The United Cement, Lime, and Gypsum Workers International Union and the Cement Employers Association agreed to establish a series of joint meetings to consider and discuss labor relation problems in the cement industry.

Public Law 93–87, an act to authorize appropriations for the construction of certain highways in accordance with title 23 of the United States Code and for other purposes, was passed on August 13, 1973.

In a suit brought by the Portland Cement Association the United States Court of Appeals for the District of Columbia Circuit ruled that Environmental Protection Agency (EPA) procedures left the question of achievability in doubt and precluded cement manufacturers from demonstrating that the standards were not achievable. The EPA, recognizing that emission of dust in excess of standards will occur for short periods during startup, shutdown, and equipment malfunctions, amended its air pollution standards for new and substantially modified cement plants.

On September 7, 1973, EPA published in the Federal Register, volume 38, No. 173, a notice of proposed rulemaking for the cement manufacturing category relating to effluent limitations guidelines for existing sources and standards of performance and pretreatment standards for new sources. The EPA also published a document entitled "Economic Analysis of Proposed Effluent Guidelines: Cement Industry." The document was available in limited quantities through EPA.

The Federal Trade Commission (FTC) approved an agreement by OKC Corp. to sell the ready-mix concrete and building materials operation of Jahncke Service, Inc. The remaining assets of Jahncke will be sold in compliance with the FTC divestiture order. Under the terms of an FTC consent order issued in June 1972, Lehigh Portland Cement Co. sold its wholly-owned subsidiary, Virginia Concrete Co., and had until June 1974 to select the divestiture of either its Miami, Fla., cement operation or certain Florida ready-mixed concrete operations. The divestiture of Botsford Ready-Mix Co. was also completed in accordance with the consent agreement entered into by the Missouri Portland Cement Co. and the FTC.

Environmental Activities.—Millions of dollars continued to be spent on advanced pollution control equipment to bring existing plants into full compliance with the National Environmental Policy Act (PL 91–109) signed into law January 1970.

Alpha Portland Industries, Inc., was installing additional pollution control equipment at its St. Louis, Mo., plant and installed an electrostatic precipitator at its Jamesville, N.Y., plant. Lone Star Industries, Inc., completed a new $3.5 million air quality control installation at its New Orleans, La., plant. Louisville Cement Co. placed a new electrostatic precipitator into service at Bessemer, Pa., to bring that plant's kilns into compliance with new emissions standards. Additional dust collection equipment was being installed by Medusa Cement Co. Div., Medusa Corp., at its York, Pa., and Charlevoix, Mich., plants. Improvement projects were begun by Martin Marietta Corp. at the Davenport, Iowa, and Calera, Ala., plants. Ideal Cement Co. Div., Ideal Basic Industries, Inc., installed new electrostatic precipitators at the Trident, Mont., and Devil's Slide, Utah, plants and at the existing Portland, Colo., plant. Projects were underway to upgrade precipitator performance at the Ada, Okla., and Mobile, Ala., plants.

Many companies were financing pollution control facilities through tax-exempt bonds and securities issued by municipalities and local government agencies. Companies will repay the loans under a lease arrangement with the local governments. These bond issues represented an effective means to raise capital at relatively low cost for essential but nonproductive equipment.

The city of Metropolis, Ill., authorized the issuance of pollution control and industrial development bonds to finance a portion of the expansion program by Missouri Portland Cement Co. at Joppa, Ill. Dundee Cement Co. negotiated the sale of $7 million of tax-exempt bonds to finance two major pollution control projects at the Dundee, Mich., plant. Cost of installation of pollution control equipment by Universal Atlas Cement Div., United States Steel Corp. at its new Leeds, Ala., plant will be financed by a $4.5 million environmental improvement revenue bond issued by the Industrial Development Board of the city of Leeds.

Amcord, Inc., was the defendant in litigation and in environmental control proceedings involving emissions from some of the company's cement plants.

Ideal Cement Co. Div., Ideal Basic Industries, Inc., phased out operations at its 60-year-old San Juan Bautista, Calif., plant and abandoned plans to construct a new plant at San Juan due to environmental problems. The company cited the attitudes toward construction, reflected by California court decisions, and voter response to environmental matters as having an influence that would restrict construction activity for the short range and have an adverse effect on the long range as well. Inflation and environmental design changes for the proposed new plant boosted the original estimated cost of $37 million to $48 million. The quarry and plant site will be rehabilitated following demolition of the old plant.

DOMESTIC PRODUCTION

PORTLAND CEMENT

The cement industry, in spite of operating clinker-producing plants at near capacity levels to meet the escalating demand for cement, had to import recordbreaking quantities of cement and clinker to meet domestic requirements.

Manufacturers in the United States and Puerto Rico produced 78.2 million tons of clinker, imported 2.7 million tons of clinker, and used stockpiled clinker to grind an alltime record 83.5 million tons of portland cement and 4 million tons of masonry cement.

Eight companies accounted for 41% of the total clinker and portland cement produced in the United States and Puerto Rico. They were: Amcord, Inc.; General Portland, Inc.; Ideal Cement Co. Div., Ideal Basic Industries, Inc.; Kaiser Cement & Gypsum Corp.; Lone Star Industries, Inc.; Marquette Cement Mfg. Co.; Martin Marietta Cement, Martin Marietta Corp.; and Universal Atlas Cement Div., United States Steel Corp.

Production Capacity.—The cement industry in the United States and Puerto Rico was capable of grinding 100.4 million tons of cement annually, based on the fineness necessary to grind Type I and II cement, and making allowances for downtime required for maintenance.

By yearend 471 kilns were operating at 166 plants, including eight white cement plants, in 41 States and Puerto Rico with an estimated 24-hour daily clinker production capacity of 274,000 tons. An average of 60 days downtime was reported for kiln maintenance and replacing refractory brick. Based on 305 days of operation, the apparent annual clinker production capacity of the industry was 84 million tons. The industry operated at 93.5% of its apparent capacity.

In addition to 166 clinker-producing plants, seven plants had only grinding mills operating on imported, purchased, or interplant transfers of clinker.

Table 2.—Finished portland cement produced, shipped, and in stock in the United States,[1] by district [2]

District	Plants active during year 1972	Plants active during year 1973	Production [3] (thousand short tons) 1972	Production [3] (thousand short tons) 1973	Shipments 1972 Quantity (thousand short tons)	Shipments 1972 Value Total (thousands)	Shipments 1972 Value Average per short ton	Shipments 1973 Quantity (thousand short tons)	Shipments 1973 Value Total (thousands)	Shipments 1973 Value Average per short ton	Stocks at mills December 31 (thousand short tons) 1972	Stocks at mills December 31 (thousand short tons) 1973
New York and Maine	10	10	5,241	5,578	5,086	$97,391	$19.15	5,679	$115,855	$20.40	464	354
Eastern Pennsylvania	r 14	14	6,028	6,158	5,912	114,018	19.29	6,210	128,998	20.77	397	353
Western Pennsylvania	5	5	2,302	2,427	2,302	41,990	18.24	2,354	42,655	18.12	225	181
Maryland and West Virginia	4	4	2,528	2,558	2,487	49,371	19.85	2,568	53,432	20.81	186	146
Ohio	8	8	2,885	3,117	2,968	57,953	19.53	3,456	73,362	21.23	356	215
Michigan	10	9	6,181	6,007	5,901	111,410	18.88	6,242	123,442	19.78	763	570
Indiana, Kentucky, Wisconsin	9	9	3,466	3,756	3,158	61,493	19.47	3,642	74,523	20.46	372	221
Illinois	3	3	1,540	1,531	1,571	33,124	21.08	1,572	36,064	22.94	180	109
Tennessee	6	6	1,715	1,579	1,695	37,176	21.93	1,711	42,402	24.78	130	80
Virginia, North Carolina, South Carolina	5	5	2,528	2,525	2,469	53,398	21.63	2,446	57,813	23.64	182	88
Georgia	3	3	1,230	1,149	1,260	27,286	21.66	1,201	28,124	23.42	66	45
Florida	4	4	2,142	2,711	2,425	59,773	24.65	2,725	72,666	26.67	101	107
Alabama	7	7	2,419	2,404	2,360	48,577	20.58	2,396	55,820	23.30	152	100
Louisiana and Mississippi	5	5	1,602	1,479	1,707	35,045	20.53	1,533	36,659	23.91	89	59
Minnesota, South Dakota, Nebraska	4	4	1,555	1,628	1,589	34,001	21.40	1,712	40,052	23.39	188	124
Iowa	5	5	2,491	2,529	2,458	49,635	20.19	2,688	59,574	22.16	278	153
Missouri	7	7	4,329	4,359	4,277	80,898	18.91	4,582	99,858	21.79	418	267
Kansas	5	5	1,986	2,036	1,889	35,432	18.76	2,026	42,172	20.82	232	163
Oklahoma and Arkansas	5	5	2,604	2,746	2,560	49,734	19.43	2,790	60,123	21.55	249	177
Texas	18	18	7,884	8,312	7,813	171,642	21.97	8,320	189,368	22.76	494	465
Wyoming, Montana, Idaho	4	4	956	1,047	946	20,276	21.43	1,046	22,437	21.45	100	116
Colorado, Arizona, Utah, New Mexico	8	8	3,145	3,441	3,560	79,868	22.43	3,854	92,861	24.09	225	192
Washington	4	4	1,426	1,462	1,239	26,848	21.67	1,194	26,651	22.32	169	192
Oregon and Nevada	3	3	831	908	854	18,914	22.15	923	20,274	21.97	44	39
Northern California	5	5	2,783	2,797	2,855	57,320	20.08	3,075	64,953	21.12	267	231
Southern California	8	8	6,609	6,705	6,231	124,988	20.06	6,321	136,939	21.66	306	324
Hawaii	2	2	379	467	402	10,732	26.70	453	13,213	29.17	27	42
Puerto Rico	3	3	1,959	2,060	1,946	31,756	16.32	2,062	41,203	19.98	39	45
U. S. total or average [4]	r 174	173	80,744	83,476	79,920	1,620,046	20.27	84,780	1,851,495	21.84	6,699	5,158
Foreign countries [5]	NA	NA	NA	NA	1,512	33,732	22.31	1,619	38,782	23.95	10	71
Total or average [4]	r 174	173	80,744	83,476	81,432	1,653,779	20.31	86,399	1,890,277	21.88	6,709	5,229

r Revised. NA Not available.
[1] Includes Puerto Rico.
[2] Includes data for eight white cement facilities: Texas (three); Pennsylvania (two); one each in California, Florida, and Wisconsin. Grinding plants (six in 1972; seven in 1973): Michigan (two in 1972; three in 1973) and includes data for Superior, Wisc.; Pennsylvania (two); and one each in Wisconsin and Virginia. Two gray plants in Michigan were phased out in 1972.
[3] Includes cement produced from imported clinker.
[4] Data may not add to totals shown, because of independent rounding.
[5] Cement imported and distributed by domestic producers only. Source of imports withheld to avoid disclosing individual company confidential data.

Table 3.—Clinker capacity and production in the United States,[1] by district, as of December 31, 1973

District	Active plants [2] Process used Wet	Dry	Both	Total	Number of kilns	Daily capacity (thousand short tons)	Average number of days for maintenance	Apparent [3] annual capacity (thousand short tons)	Production [4] (thousand short tons)	Percent utilized
New York and Maine	7	3	--	10	22	20	81	5,680	5,354	94.3
Eastern Pennsylvania	3	8	1	12	52	20	75	5,809	5,923	102.0
Western Pennsylvania	3	2	--	5	13	8	71	2,353	2,371	100.8
Maryland and West Virginia	2	2	--	4	10	8	44	2,566	2,508	97.7
Ohio	5	3	--	8	22	10	19	3,455	3,074	89.0
Michigan	5	1	--	6	27	17	21	5,842	4,805	82.2
Indiana, Kentucky, Wisconsin	3	5	--	8	20	12	70	3,537	3,389	95.8
Illinois	--	3	--	3	8	6	103	1,572	1,419	90.3
Tennessee	6	--	--	6	13	6	80	1,711	1,660	97.0
Virginia, North Carolina, South Carolina	3	1	--	4	11	7	42	2,261	1,959	86.6
Georgia	1	2	--	3	7	4	65	1,201	1,086	90.4
Florida	4	--	--	4	12	7	24	2,723	2,182	80.1
Alabama	5	2	--	7	18	8	65	2,396	2,393	99.9
Louisiana and Mississippi	5	--	--	5	13	5	58	1,533	1,469	95.8
Minnesota, South Dakota, Nebraska	3	1	--	4	13	5	23	1,712	1,500	87.6
Iowa	3	2	--	5	19	8	29	2,689	2,436	90.6
Missouri	5	2	--	7	12	15	59	4,584	4,154	90.6
Kansas	3	2	--	5	16	7	75	2,027	1,930	95.2
Oklahoma and Arkansas	3	2	--	5	11	9	55	2,789	2,600	93.2
Texas	14	3	1	18	47	26	45	8,318	7,853	94.4
Wyoming, Montana, Idaho	3	--	1	4	9	4	104	1,045	1,027	98.3
Colorado, Arizona, Utah, New Mexico	3	5	--	8	19	12	44	3,855	3,322	86.2
Washington	3	1	--	4	7	4	66	1,194	1,151	96.4
Oregon and Nevada	2	1	--	3	7	3	57	923	911	98.7
Northern California	3	2	--	5	15	11	85	3,075	2,728	88.7
Southern California	2	5	1	8	33	22	78	6,320	6,534	103.4
Hawaii	1	1	--	2	3	2	138	453	469	103.5
Puerto Rico	3	--	--	3	12	8	107	2,062	2,005	97.2
Total or average	103	59	4	166	471	274	60	83,685	78,212	93.5

[1] Includes Puerto Rico.
[2] Includes white cement manufacturing facilities. Plants not active December 31, 1973: Ideal Cement Co. closed San Juan Bautista plant in July 1973; Amcord, Inc. ceased production at Port Huron and Brennan Ave. plants in January 1973.
[3] Calculated on individual company data: 365 days, minus average days for maintenance, times the reported 24 hour capacity.
[4] Includes production reported for plants which added or shut down kilns during the year.

Table 4.—Daily clinker capacity, December 31 [1]

Short tons per 24-hour period	Number of plants [2]	Kilns [3]	Total capacity	Percent of total capacity
1972:				
Less than 600	10	17	4,860	1.9
600 to 1,150	47	93	40,646	15.9
1,150 to 1,700	60	175	80,808	31.5
1,700 to 2,300	29	77	55,384	21.6
2,300 to 2,800	9	31	22,646	8.8
2,800 and over	14	68	52,073	20.3
Total	169	461	256,417	100.0
1973:				
Less than 600	7	10	3,498	1.3
600 to 1,150	43	81	36,540	13.3
1,150 to 1,700	52	143	71,741	26.2
1,700 to 2,300	37	118	69,362	25.4
2,300 to 2,800	7	22	17,692	6.5
2,800 and over	20	97	74,725	27.3
Total	166	471	273,558	100.0

[1] Includes Puerto Rico.
[2] Includes white-cement-producing facilities.
[3] Total number in operation at plants.

Capacity Changes.—An explosion and fire in recently installed electrostatic precipitators forced Marquette Cement Mfg. Co. to shut down its new kiln and cut back production at the Oglesby, Ill., plant from May through August. In December, two old 11-foot-diameter by 200-foot-long wet process kilns were shut down. The company also had reduced production at the Cape Girardeau, Mo., plant earlier in the year because of flooding of the Mississippi River.

Glens Falls Cement Co. Div. of The Flintkote Co. completed installation of a new 15-foot-diameter by 235-foot-long dry process kiln equipped with a 220-foot-high, four-stage counter flow suspension preheater at its Glens Falls, N.Y., plant. The new kiln replaced three old wet process kilns with a combined capacity of 320,000 tons annually.

Early in the year a new kiln with a capacity of 360,000 tons went on line at the Louisville Cement Co., Speed, Ind., plant. Operation of three old kilns, two dating back to 1910, were discontinued. This change resulted in a net increase in capacity of 188,000 tons.

Ideal Cement Co. Div. of Ideal Basic Industries, Inc., completed a $12 million modernization program at Trident, Mont. The successful startup of a new 12-foot-diameter by 450-foot-long kiln, which replaced four old kilns, raised the plant's capacity 16% to 333,000 tons per year.

At Miami, Fla., General Portland, Inc., completed modification of two kilns in a modernization program.

Monarch Cement Co. completed installation of a new dry process kiln with a preheater at Humboldt, Kans. The new 12-foot-diameter by 165-foot-long kiln was put onstream in October. A second identical kiln was scheduled for operation in 1975. Two old kilns will be phased out in 1974.

In October Coplay Cement Mfg. Co. reactivated six kilns at its recently purchased Egypt, Pa., plant, formerly the property of the Giant Portland Cement Co. and now an integral part of the Coplay plant. The addition of the six kilns increased the annual capacity of the new plant complex to 1,350,000 tons.

Arizona Portland Cement Co. Div. of California Portland Cement Co. completed the major portion of a modernization and expansion program at its Rillito, Ariz., plant. Included in this phase of the program was the startup of the new raw crusher, 4-mile belt conveyor from quarry to plant site, raw mill, and preheater kiln. Additional expansion currently underway at the Rillito plant includes a new finish grinding mill, additional bulk loading facilities, and dust collecting equipment to be installed on the original facilities. Completion of the entire program in early 1974 will more than double the plant's present capacity of 500,000 to 1,150,000 tons annually.

The new kiln under construction for Giant Portland Cement Co. at Harleyville, S.C., did not become operational in 1973 as expected. The new kiln is scheduled to be completed early in 1974 and will replace the smallest of four old kilns currently in production.

Planned Expansion and New Plants.—Major construction projects undertaken by Ideal Cement Co. Div. of Ideal Basic Industries, Inc., were proceeding satisfactorily. A new cement-producing facility adjacent to the present plant at Portland, Colo., was nearing completion with operations scheduled to begin June 1974. The new addition will increase the plant's capacity from 415,000 to 885,000 tons of cement per year. The new plant at Trident, Mont., was designed for coal-firing in anticipation of possible natural gas and oil shortages. The company was proceeding with a feasibility study on the construction of a new cement plant in the Mobile, Ala., area.

Expansion programs by OKC Corp. at its Pryor, Okla., and New Orleans, La., plants were nearing completion. A new finish grinding mill and kiln modifications at Pryor will increase the capacity of the Oklahoma Cement Co. plant to 425,000 tons of cement annually. The completion of a second kiln, raw grinding mill, and finish grinding mill at New Orleans will more than double the output of the Louisiana Cement Co. plant.

Medusa's new kiln at Clinchfield, Ga., was nearing completion and was due onstream early in 1974. The 15-foot-diameter by 220-foot-long kiln with suspension preheater will replace three short wet kilns now in operation. The new facilities are expected to reduce by more than 50% the Btu's presently required to produce a ton of cement.

Six other plant expansions and modernization programs were in various stages of construction and scheduled for completion in 1974: Santee Portland Cement Co., Holly Hill, S.C.; Diamond-Kosmos Cement Div. of The Flintkote Co., Kosmosdale, Ky.; Gifford-Hill Portland Cement Co., Harleyville, S.C.; Texas Industries, Inc., Columbus, Miss.; Centex Cement Corp., LaSalle, Ill.; Southwestern Portland Cement Co., subsidiary of Southdown, Inc., Fairborn, Ohio.

An $11.5 million expansion was underway at the Kaiser Cement & Gypsum Corp., Longhorn Div., cement plant at San Antonio, Tex. It will include an efficient dry-process kiln that will consume less fuel per ton than the plant's three existing wet process kilns. The clinker capacity of the plant will nearly double to 785,000 tons per year when completed early in 1975. Additional air pollution control equipment will be included in the expansion to keep the plant in compliance with environmental regulations.

Lehigh Portland Cement Co. announced plans to expand the Mitchell, Ind., cement plant by 50% to an annual capacity of 750,000 tons. The project is scheduled for completion in 1976 at an estimated cost of approximately $10 million.

Martin Marietta was adding a new finishing mill and storage silos in an effort to expand the production capacity of its Calera, Ala., plant.

United States Steel's Universal Atlas Cement Div. started a modernization project which will almost double the production capability of the Leeds, Ala., plant. The new manufacturing facility will consist of a dry-process preheater kiln, a new raw mill capable of drying raw materials in the mill circuit replacing the present wet grinding mills, and a new clinker grinding mill. When the new facilities are completed, they will have a cement processing capacity of more than 600,000 tons per year.

Lone Star Industries, Inc., and Canada Cement Lafarge Ltd., which is 50.1% owned by Ciments Lafarge, Paris, France, signed a joint-venture agreement to form Citadel Cement Corp. to produce hydraulic cement. The new company with headquarters in Atlanta, Ga., will begin operations January 1, 1974. Initial assets include Lone Star plants in Roanoke, Va., and Birmingham, Ala. Citadel Cement Corp. continued the $35 million expansion program that will double annual capacity at the Roanoke plant to 1.2 million tons when completed by mid-1975. The company plans to start a $50 million construction project on a new plant with an annual capacity of 750,000 tons at an undisclosed location to serve the eastern Gulf Coast.

Missouri Portland Cement Co. began a $30 million expansion program that will more than double the production capacity of its Joppa, Ill., plant. New equipment will include a dry process kiln equipped with a single-stage preheater having an annual capacity of 750,000 tons and pollution control facilities. Although the expansion program will span 10 years, the major portions were scheduled for completion by mid-1975. A 7,500-horsepower finish grinding mill, one of the largest mills in the United States, will also be installed in the new facility.

Florida Mining & Materials Corp. announced plans to begin construction immediately of a new cement plant 7 miles north of Brooksville, Fla. The plant, scheduled for completion late in 1975, will have a dry-process kiln equipped with a suspension preheater and an annual capacity of 546,000 tons.

Portland Cement Co. of Utah announced a $5.5 million modernization program without a guarantee of increased production for its plant at Salt Lake City.

Alpha Portland Industries, Inc., planned to increase the capacity of its St. Louis, Mo., plant to 340,000 tons per year.

Amcord, Inc., announced an expansion project which will increase the volume of the Stockerton, Pa., plant by 16%.

Additional expansion programs currently underway are listed below. Scheduled completion dates are shown in parentheses: Whitehall Cement Mfg. Co., Cementon, Pa. (1975); Coplay Cement Mfg. Co., Coplay, Pa. (1975); Monolith Portland Cement Co., Monolith, Calif. (1974–76); Southeastern Materials, Inc., Miami, Fla. (1975); and Pennsuco Cement & Aggregates, Inc., subsidiary of Maule Industries, Inc. (1974–75).

Puerto Rican Cement Co., Toa Alta, Puerto Rico, San Juan Cement Co., Dorado, Puerto Rico, and Hawaiian Cement Corp. at Barbers Point, Hawaii, are also expanding plant facilities.

Cement Grinding Facilities.—The old Jefferson Avenue plant of American Cement Corp. in Detroit, Mich., purchased by Edward C. Levy Co. in June 1972, began to operate under the name of Jefferson Marine Terminal in 1973, grinding clinker imported from Sweden and Canada.

In March, Pennsuco Cement & Aggregates, Inc., placed an order for an additional 6,300-horsepower grinding mill to be installed early in 1975 that will increase the grinding capacity by nearly 1 million tons.

Gulf Coast Portland Cement Co. Div. of McDonough Co. completed installation of an 11- by 34-foot finish mill at its plant in Houston, Tex.

River Cement Co. installed a 13- by 34-foot, 3,500-horsepower finish-grinding mill with an annual capacity of 178,000 tons. The plant's annual grinding capacity will be increased to 1,128,000 tons.

Ash Grove Cement Co. completed installation of new crushing facilities and two 13- by 47-foot, 4,400-horsepower finishing mills at its plant in Louisville, Nebr. Work on the new dry process kiln continued.

National Portland Cement Co. of Florida was expected to be in operation early in 1974. The new plant, with an annual capacity of 282,000 tons, will operate on clinker imported from Europe.

In addition to these grinding plants, the following companies operate grinding facilities on imported, purchased, or interplant transfer of clinker: Wyandotte Cement, Inc., at Wyandotte, Mich., and Universal Atlas Cement Div. of United States Steel Corp. at Milwaukee, Wis.; Huron Cement Div. of National Gypsum Co. at Superior, Wis.; Allentown Portland Cement Co. Div. of National Gypsum Co. at West Conshohocken, Pa.; and G. & W. H. Corson, Inc., at Plymouth Meeting, Pa.

Raw Materials.—Several companies were involved in exploration and development work for basic raw materials. Ideal Basic Industries, Inc. completed a $4.5 million program which will triple the capacity of limestone operations at Texada Island, North Vancouver, Canada. The plant supplies high-quality limestone to the company's Seattle cement plant and to other cement and chemical companies in the Pacific Northwest.

Lehigh Portland Cement Co. signed an agreement with Brinco Ltd. of Montreal, Canada, for the joint examination of a limestone deposit in the Port-au-Port Peninsula of western Newfoundland.

Martin Marietta Cement announced that new limestone and clay deposits for future development, calculated to last 30 years or more, were added to reserves for the Georgia plant and an additional limestone source was added to reserves of the Colorado plant.

MASONRY CEMENT

Demand for masonry cement continued at a recordbreaking pace. Total shipments were 4,130,000 tons, exceeding the previous alltime high established in 1972 by 7%. The unit value increased $2.91 per ton to $29.43, and the total value advanced 19% to $121.5 million.

During the year 42 companies manufactured masonry cement at 115 plants. The combined output of six companies accounted for 52% of the total masonry cement produced in the United States. The companies in descending order were Louisville Cement Co.; Martin Marietta Corp.; Marquette Cement Mfg. Co.; General Portland, Inc.; Ideal Cement Co., Div. of Ideal Basic Industries, Inc.; and Medusa Cement Co., Div. of Medusa Corp. Masonry cement

Table 5.—Raw materials used in producing portland cement in the United States[1]

(Thousand short tons)

Raw materials	1972	1973
Calcareous:		
Limestone (includes aragonite)	84,922	86,699
Cement rock (includes marl)	25,879	26,067
Oystershell	5,081	5,144
Argillaceous:		
Clay	8,062	7,931
Shale	4,096	4,099
Other (includes staurolite, bauxite, aluminum dross, pumice, and volcanic material)	110	240
Siliceous:		
Sand	1,993	2,053
Sandstone and quartz	781	748
Ferrous:		
Iron ore, pyrites, millscale, and other iron-bearing material	839	968
Other:		
Gypsum and anhydrite	4,094	4,253
Blast furnace slag	759	682
Fly ash	271	299
Other, n.e.c	33	5
Total	136,920	139,188

[1] Includes Puerto Rico.

was produced exclusively at only three plants: Riverton Lime & Stone Co., Inc., Riverton, Va.; M. J. Grove Lime Co. Div. of The Flintkote Co., Frederick, Md.; and Martin Marietta Cement, a subsidiary of Martin Marietta Corp., Birmingham, Ala. Quantities produced on the job by masons who prefer to purchase portland cement and add clay or lime for plasticity are not included in table 6.

ALUMINOUS CEMENT

A totally new patented process for the production of calcium aluminate cements was developed and put on stream by Universal Atlas Cement Div. of United States Steel Corp. at its Buffington complex in Gary, Ind. Stoichiometric mixes of finely powdered limestone and bauxite are pelletized and passed through a drier/preheater before being sintered in a specially designed high-temperature rotary kiln. The sintered pellets are then ground into calcium aluminate cements.

The Aluminum Co. of America operated a calcium aluminate plant at Bauxite, Ark.

The completion in June of a $3 million grinding and packing facility at Norfolk, Va., will enable Lone Star Lafarge Co., the joint venture formed in 1970, to distribute to customers in the United States calcium aluminate cement produced from imported clinker.

ENERGY

Energy economics has become an absolute operating necessity to an industry that requires 490 trillion Btu's of fossil fuels energy and 10.9 billion kilowatt-hours of electrical energy. Based on national totals, the average cement plant used 5.6 million Btu's of fuel and 124 kilowatt-hours of electricity to produce 1 ton of cement.

The cost of fuel and electrical energy, representing 40% of the production cost, was expected to rise 25% in some areas and nearly double in Hawaii where only oil is burned.

In an industry which recently became largely dependent on oil and natural gas because of convenience, availability, relatively low prices, and strict environmental regulations, many plants are now returning to coal as a means of assuring uninterrupted production. Modifications of existing fuel systems will hopefully be completed before shortages of natural gas and oil reach a point where production might be curtailed. Capital cost of these changes are expected to be substantial.

Plans to assure adequate supplies of fuel were underway by many companies. Ideal Basic Industries, Inc., picked up an option to explore a coal property in Oklahoma, negotiated long-term contracts to purchase low-sulfur coal for two of its cement plants, and signed a letter of intent with Rocky Mountain Energy Co., a subsidiary of Union Pacific Corp., to form a joint venture to

Table 6.—Prepared masonry cement produced and shipped in the United States, by district

District	Plants active during year		Production (thousand short tons)		Shipments from mills					
					1972			1973		
					Quantity (thousand short tons)	Value		Quantity (thousand short tons)	Value	
	1972	1973	1972	1973		Total (thousands)	Average per ton [1]		Total (thousands)	Average per ton [1]
New York and Maine	6	6	129	126	126	$3,004	$23.84	134	$3,609	$26.93
Eastern Pennsylvania	r 9	10	296	326	289	8,016	27.74	321	9,488	29.56
Western Pennsylvania	5	5	162	166	162	4,384	27.06	169	4,955	29.32
Maryland and West Virginia	3	3	151	167	145	3,406	23.49	163	4,402	27.01
Ohio	5	5	160	169	161	4,684	29.09	176	5,641	32.05
Michigan	4	4	259	249	250	5,959	23.84	247	6,185	25.04
Indiana, Kentucky, Wisconsin	5	5	520	559	509	12,400	24.36	554	13,099	23.64
Illinois	3	3	76	85	80	2,483	31.04	88	2,901	32.97
Tennessee	4	5	217	229	176	4,104	23.32	201	7,908	39.34
Virginia, North Carolina, South Carolina	5	5	389	417	397	12,122	30.53	416	13,593	32.68
Georgia	5	5	234	288	68	1,569	23.07	67	2,126	31.73
Florida					213	6,901	32.40	256	8,706	34.01
Alabama	7	7	411	416	407	11,221	27.57	425	13,074	30.76
Louisiana and Mississippi	2	2	36	40	49	1,091	22.27	51	1,479	29.00
Minnesota, South Dakota, Nebraska	4	3	34	25	36	988	27.44	28	866	30.93
Iowa	3	3	68	61	66	1,916	29.03	68	2,351	34.57
Missouri	5	4	85	77	80	1,859	23.24	84	2,400	28.57
Kansas	5	5	54	70	59	1,452	24.61	73	2,068	28.33
Oklahoma and Arkansas	5	5	119	125	119	2,796	23.50	126	2,954	23.44
Texas	12	12	241	250	217	5,812	26.78	234	6,606	28.23
Wyoming, Montana, Idaho	4	4	5	8	7	174	24.86	7	183	26.14
Colorado, Arizona, Utah, New Mexico	6	6	146	145	144	3,371	23.41	145	4,204	28.99
Washington	4	4	7	7	6	170	28.33	6	169	28.17
Oregon and Nevada	--	--	--	--	--	--	--	1	23	23.00
Northern California	1	1	--	--	W	W	W	(2)	3	--
Southern California	1	1	--	1	W	W	W	1	18	18.00
Hawaii	2	2	13	16	13	384	29.54	16	537	33.56
U.S. total or average [3]	r 115	115	3,812	4,022	3,776	100,269	26.53	4,057	119,547	29.47
Foreign countries [4]	NA	NA	NA	NA	71	1,845	26.04	73	1,981	27.14
Grand total or average [3]	r 115	115	3,812	4,022	3,848	102,114	26.52	4,130	121,528	29.43

r Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data; included with "Foreign countries."
1 Computed prior to rounding.
2 Less than 500 short tons.
3 Data may not add to totals shown because of independent rounding.
4 Cement imported and distributed by domestic producers only. Source of imports withheld to avoid disclosing individual company confidential data.

Table 7.—Clinker produced in the United States, by kind of fuel[1]

Year and fuel	Clinker produced: Plants	Clinker produced: Quantity (thousand short tons)	Clinker produced: Percent of total	Fuel consumed: Coal (thousand short tons)	Fuel consumed: Oil (thousand 42-gallon barrels)	Fuel consumed: Natural gas (thousand cubic feet)
1972:						
Coal	36	[2] 14,046	18.2	3,646	--	--
Oil	18	[2] 9,206	11.9	--	9,276	--
Natural gas	29	[2] 12,098	15.6	--	--	75,474,261
Coal and oil	11	6,276	8.1	1,257	484	--
Coal and natural gas	27	9,585	12.4	1,169	--	36,182,730
Oil and natural gas	34	17,003	22.0	--	2,002	90,385,803
Coal, oil, and natural gas	15	9,164	11.8	1,267	469	21,307,728
Total	170	77,378	100.0	7,339	12,231	223,350,522
1973:						
Coal	41	19,009	24.3	4,727	--	--
Oil	16	9,444	12.1	--	9,381	--
Natural gas	31	11,550	14.8	--	--	78,681,049
Coal and oil	11	5,944	7.6	1,026	1,331	--
Coal and natural gas	28	11,058	14.1	1,414	--	40,372,442
Oil and natural gas	35	18,819	24.1	--	2,570	92,263,767
Coal, oil, and natural gas	4	2,388	3.0	308	118	5,707,972
Total	166	78,212	100.0	7,475	13,400	217,025,230

[1] Includes Puerto Rico.
[2] Average consumption of fuel per ton of clinker produced as follows: 1972—coal, 0.25958 ton; oil, 1.008 barrels; and natural gas, 6,239 cubic feet. 1973—coal, 0.24867 ton; oil, 0.993 barrels; and natural gas, 6,812 cubic feet.

Table 8.—Clinker produced and fuel consumed by the portland cement industry in the United States, by process[1]

Year and process	Clinker produced: Plants active during year	Clinker produced: Quantity (thousand short tons)	Clinker produced: Percent of total	Fuel consumed: Coal (thousand short tons)	Fuel consumed: Oil (thousand 42-gallon barrels)	Fuel consumed: Natural gas (thousand cubic feet)
1972:						
Wet	r 106	r 45,741	r 59.1	4,158	r 8,728	147,540,429
Dry r	60	29,767	38.5	3,075	3,310	67,924,453
Both	3	1,870	2.4	106	193	7,885,640
Total	r 169	77,378	100.0	7,339	12,231	233,350,522
1973:						
Wet	103	45,955	58.8	4,270	9,732	143,188,081
Dry	59	29,911	38.2	3,098	3,483	62,683,137
Both	4	2,346	3.0	107	185	11,154,012
Total	166	78,212	100.0	7,475	13,400	217,025,230

r Revised.
[1] Includes Puerto Rico.

Table 9.—Electric energy used at portland cement plants[1] in the United States[2] by process

Year and process	Electric energy used: Generated at portland cement plants: Active plants	Generated: Quantity (million kilowatt-hours)	Purchased: Active plants	Purchased: Quantity (million kilowatt-hours)	Total: Quantity (million kilowatt-hours)	Total: Percent	Finished cement produced (thousand short tons)	Average electric energy used per ton of cement produced (kilowatt-hours)
1972:								
Wet	7	204	r 103	r 5,678	r 5,882	r 55.8	r 47,770	r 123.1
Dry[3]	8	646	r 64	r 3,767	r 4,413	r 41.8	r 31,061	r 142.1
Both	--	--	3	257	257	2.4	1,913	--
Total	15	850	r 170	9,702	10,552	100.0	80,744	130.7
Percent of total electric energy used	--	8.1	--	91.9	--	--	--	--
1973:								
Wet	7	171	101	5,902	6,073	56.0	49,100	123.8
Dry[3]	7	548	66	3,913	4,461	41.1	32,011	139.1
Both	--	--	4	317	317	2.9	2,363	134.2
Total	14	719	171	10,132	10,851	100.0	[4] 83,476	130.0
Percent of total electric energy used	--	6.6	--	93.4	--	--	--	--

r Revised.
[1] Includes grinding plants and white cement facilities.
[2] Includes Puerto Rico.
[3] Includes data for grinding plants: 6 in 1972; 7 in 1973.
[4] Data does not add to total shown because of independent rounding.

reopen and expand the presently inactive Stansbury underground coal mine owned by Rocky Mountain Energy Co. Initial production exceeding 1 million tons of coal per year was planned to begin in 1975 at the mine near Rock Springs, Wyo.

As the result of an active program during the last 2 years, Kaiser Cement & Gypsum Corp. obtained rights to natural gas production and purchased natural gas reserves in Texas. Its gas supplies will provide the San Antonio cement plant with a portion of its fuel requirements during periods of interruption from normal sources. Natural gas exploration programs initiated by Lone Star Industries, Inc. in 1972 were showing excellent progress. During the year, a natural gas drilling program launched in New Mexico, Oklahoma, and Texas by the Diversified Industries Group resulted in 25 successful well completions out of 28 starts. Continuation of the gas development program is planned for the next several years.

A venture by Medusa to explore for gas and oil has proved successful and should supply part of its fuel requirements next year. Exploration is expected to increase in 1974.

TRANSPORTATION

Spring floods on the Mississippi, Missouri, and Ohio Rivers affected transportation. High water at shipping and receiving docks upset normal patterns of barge traffic to terminals, causing shortages of cement in areas dependent on river transportation.

Cement was transported from manufacturing plants in bulk or in containers, by truck, rail, or waterway. Of the 84,424,000 tons of portland cement shipped from plants, 79% was sent directly to customers from producing plants and 21% was transferred to distribution facilities strategically located in principal market areas for customer delivery by short-haul truck loads. Eleven percent of the cement shipped from plants to terminal and to customer moved via low-cost water transportation. One producer, interestingly, calculated that river transportation required 80% less fuel than truck transportation to move 1 ton of cement 1 mile. Although trucks were used to haul 84% of the total cement to customers, they accounted for only 5% of the total cement transferred from plants to terminals. Manufacturers continued to use railroad and waterways almost equally as the principal means of supplying distribution centers.

Table 10.—Shipments of portland cement from mills in the United States, in bulk and in containers, by type of carrier [1]

(Thousand short tons)

Year and type of carrier	Shipments from plants to terminal		Shipments to ultimate consumer: From terminal to consumer		Shipments to ultimate consumer: From plant to consumer		Total shipments
	In bulk	In containers	In bulk	In containers	In bulk	In containers	
1972:							
Railroad	9,020	295	835	213	11,126	714	12,888
Truck	516	60	17,940	848	43,278	5,253	67,319
Barge and boat	8,426	5	312	--	843	--	1,155
Unspecified [2]	--	--	--	--	63	7	70
Total	17,962	360	19,087	1,061	55,310	5,974	[3] 81,432
1973:							
Railroad	7,763	253	1,418	48	11,111	598	13,175
Truck	877	89	17,381	734	48,516	5,547	72,178
Barge and boat	8,670	38	67	--	902	--	969
Unspecified [2]	--	--	18	--	49	11	78
Total	17,310	380	18,884	782	60,578	6,156	[3 4] 86,399

[1] Includes Puerto Rico.
[2] Includes cement used at plant.
[3] Bulk shipments were 91.4% (74,397 tons); container (bag) shipments were 8.6% (7,035 tons) for 1972. Bulk shipments were 92.0% (79,462 tons); container (bag) shipments were 8.0% (6,938 tons) for 1973.
[4] Data does not add to total shown because of independent rounding.

A novel aircraft method was developed for transferring cement to Alaska for its oil exploration program. Stored cement was blown into tanks fitted inside the compartments of a cargo carrier. The cement was discharged at the destination by reversing the procedure. Each loading and unloading operation required approximately 15 minutes to dispose of 39,000 pounds of cement.

CONSUMPTION AND USES

Shipments of cement by State of destination are considered to be consumption. Consumption of portland cement continued at record levels for the third consecutive year, surpassing the 1972 record by 7%.

Domestic producers shipped 86.4 million tons of portland cement, which included 1.7 million tons of imported cement. In addition to the imported cement shipped by domestic manufacturers, 1.9 million tons of portland cement was imported and shipped or used by others not producing cement in the United States and Puerto Rico.

Consumption was greater than in the previous year in all but seven States. The largest increase was in Florida, with 849,000 tons; Illinois, 543,000; Ohio, 497,000; New York, 433,000; and in Nebraska, Wisconsin, and Pennsylvania, the increase was in excess of 200,000 tons. The seven States showing decreased activity included Georgia, with a decline of 85,000 tons, followed by Michigan, Louisiana, Virginia, Rhode Island, Vermont, and Alaska.

Demand in excess of available supplies placed shipments of cement under allocation in some areas of the country during part of the year.

Ready-mix concrete producers were the primary consumers of portland cement, accounting for 66% of the total cement shipped by domestic producers. Concrete product manufacturers used 14% of the cement shipments to make concrete block and pipe, precast, prestressed concrete, and other concrete products. Building material dealers received 8% of the total cement consumed; direct shipments to highway contractors were 7%; other contractors received 3%; and Federal, State, or other governmental bodies and other miscellaneous users accounted for the remaining 2%.

Table 11.—Cement shipments, by destination and origin [1]

(Thousand short tons)

	Portland cement [2]		Masonry cement	
	1972	1973	1972	1973
Destination:				
Alabama	1,261	1,407	110	119
Alaska [3]	63	53	W	W
Arizona	1,544	1,711	W	W
Arkansas	838	866	65	71
California, northern	3,026	3,135	(4)	(4)
California, southern	5,465	5,473	(4)	(4)
Colorado	1,425	1,593	45	46
Connecticut [3]	874	906	16	16
Delaware [3]	191	219	10	13
District of Columbia [3]	224	230	27	22
Florida	5,001	5,850	377	455
Georgia	2,506	2,421	243	242
Hawaii	402	453	13	16
Idaho	414	429	1	2
Illinois	3,606	4,149	116	129
Indiana	1,793	1,838	115	125
Iowa	1,601	1,744	25	27
Kansas	1,048	1,126	24	27
Kentucky	1,125	1,150	104	114
Louisiana	2,358	2,335	73	75
Maine	257	278	13	13
Maryland	1,432	1,525	118	129
Massachusetts [3]	1,411	1,460	49	51
Michigan	3,231	3,198	179	179
Minnesota	1,602	1,762	52	54
Mississippi	929	968	72	77
Missouri	1,798	1,876	41	45
Montana	242	282	3	3
Nebraska	956	1,192	13	14
Nevada	402	467	(4)	(4)
New Hampshire [3]	243	279	13	13
New Jersey [3]	2,174	2,252	80	87
New Mexico	566	595	16	17
New York, eastern	729	927	42	43
New York, western	1,108	1,176	58	66
New York, metropolitan [3]	1,796	1,963	45	49
North Carolina	1,873	1,972	269	288
North Dakota [3]	312	347	7	8
Ohio	3,340	3,837	230	237
Oklahoma	1,398	1,419	64	66
Oregon	806	835	(4)	(4)
Pennsylvania, eastern	2,070	2,276	73	86
Pennsylvania, western	1,203	1,206	82	90
Puerto Rico	1,904	1,947	--	--
Rhode Island [3]	200	187	6	6
South Carolina	910	1,025	166	162
South Dakota	319	334	7	10
Tennessee	1,608	1,744	192	209
Texas	6,786	6,821	179	192
Utah	652	686	1	1
Vermont [3]	154	143	6	6
Virginia	2,107	2,084	232	250
Washington	1,091	1,104	7	7
West Virginia	557	707	36	43
Wisconsin	1,619	1,837	65	68
Wyoming	194	204	2	3
Total United States	82,744	88,003	3,782	4,071
Foreign countries [5]	64	259	89	88
Total shipments	82,808	88,262	3,871	4,159
Origin:				
United States [6]	77,974	82,719	3,779	4,057
Puerto Rico	1,946	2,062	--	--
Foreign [7]	2,888	3,481	92	102
Total shipments	82,808	88,262	3,871	4,159

W Withheld to avoid disclosure of individual company confidential data; included with "Foreign countries."

[1] Includes cement produced from imported clinker and imported cement shipped by domestic producers, Canadian cement manufacturers, and other importers.

[2] Excludes cement used in the manufacture of prepared masonry cement.

[3] Has no cement producing plants.

[4] Less than 500 short tons.

[5] Direct shipments by producers to foreign countries, U.S. possessions and territories, and also including States indicated by symbol W.

[6] Includes cement produced from imported clinker by domestic producers (1972—1,576,000; 1973—2,673,000).

[7] Includes imported cement distributed by domestic producers, Canadian cement manufacturers, and other importers. Origin of imports withheld to avoid disclosing individual company confidential data.

Table 12.—Cement shipments, by type of customer in 1973

(Thousand short tons)

District origin	Building material dealers		Concrete product manufacturers		Ready-mixed concrete		Highway contractors		Other contractors		Federal, State and other government agencies		Miscellaneous including own use		Total
	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	
New York and Maine	420	7.4	761	13.4	4,225	74.4	191	3.4	44	0.8	2	(1)	36	0.6	5,679
Eastern Pennsylvania	641	10.3	1,485	23.9	3,646	58.7	303	4.9	31	.5	11	0.2	93	1.5	6,210
Western Pennsylvania	270	11.5	373	15.8	1,399	59.4	243	10.3	65	2.8	--	--	4	.2	2,354
Maryland and West Virginia	113	4.4	588	22.9	1,713	66.7	54	2.1	54	2.1	13	.5	33	1.3	2,568
Ohio	186	5.4	593	17.2	2,188	63.3	440	12.7	17	.5	--	--	32	.9	3,456
Michigan	394	6.3	957	15.3	4,142	66.4	637	10.2	57	.9	10	.2	45	.7	6,242
Indiana, Kentucky, Wisconsin	269	7.4	530	14.6	2,507	68.8	292	8.0	25	.7	--	--	19	.5	3,642
Illinois	192	12.2	109	6.9	1,071	68.1	173	11.0	20	1.3	4	.3	3	.2	1,572
Tennessee	103	6.0	340	19.9	1,147	67.1	74	4.3	21	1.2	10	.6	16	.9	1,711
Virginia, North Carolina South Carolina	205	8.4	387	15.8	1,591	65.1	228	9.3	31	1.3	3	.1	1	(1)	2,446
Georgia	194	16.2	168	14.0	686	57.1	51	4.2	60	5.0	5	.4	37	3.1	1,201
Florida	230	8.4	419	15.4	1,790	65.7	181	6.6	79	2.9	13	.5	13	.5	2,725
Alabama	204	8.5	396	16.5	1,463	61.1	104	4.3	219	9.1	9	.4	1	.1	2,396
Louisiana and Mississippi	119	7.8	138	9.0	802	52.3	205	13.4	194	12.6	44	2.9	31	2.0	1,533
Minnesota, South Dakota, Nebraska	113	6.6	132	7.7	1,023	59.7	352	20.6	82	4.8	8	.5	2	.1	1,712
Iowa	184	6.8	437	16.3	1,751	65.1	254	9.4	26	1.0	21	.8	15	.6	2,688
Missouri	193	4.2	429	9.3	3,431	74.9	443	9.7	54	1.2	9	.2	23	.5	4,582
Kansas	166	8.2	198	9.8	1,445	71.3	101	5.0	62	3.1	1	(1)	53	2.6	2,026
Oklahoma and Arkansas	218	7.8	270	9.7	1,727	61.9	424	15.2	86	3.1	2	.1	63	2.2	2,790
Texas	608	7.3	719	8.6	5,227	62.8	514	6.2	509	6.1	89	1.1	654	7.9	8,320
Wyoming, Montana, Idaho	41	3.9	80	7.6	768	73.4	30	2.9	74	7.1	2	.2	51	4.9	1,046
Colorado, Arizona, Utah, New Mexico	279	7.2	377	9.8	2,821	73.2	122	3.2	149	3.9	1	(1)	105	2.7	3,854
Washington	64	5.4	216	18.1	808	67.7	65	5.4	26	2.2	5	.4	10	.8	1,194
Oregon and Nevada	75	8.1	65	7.0	633	68.6	68	7.4	50	5.4	10	1.1	22	2.4	923
Northern California	206	6.7	326	10.6	2,207	71.8	165	5.4	77	2.5	3	.1	91	2.9	3,075
Southern California	631	10.0	803	12.7	4,399	69.6	274	4.3	114	1.8	26	.4	74	1.2	6,321
Hawaii	20	4.4	59	13.0	362	79.9	4	.9	7	1.6	--	--	1	.2	453
Puerto Rico	638	30.9	230	11.2	1,038	50.3	21	1.0	86	4.2	37	1.8	12	.6	2,062
Imports [2]	108	6.7	217	13.4	1,127	69.6	85	5.2	71	4.4	3	.2	8	.5	1,619
Total [3]	7,084	8.2	11,802	13.7	57,137	66.1	6,098	7.0	2,390	2.8	341	.4	1,548	1.8	86,399

[1] Less than 0.1%.
[2] Cement imported and distributed by domestic producers only. Source of imports withheld to avoid disclosing individual company confidential data.
[3] Data may not add to totals shown because of independent rounding.

PRICES

The average mill value[2] of portland cement (all types) was $21.88 per ton in 1973, an increase of $1.57 per ton. The mill value ranged from a low of $18.12 in western Pennsylvania to a high of $29.17 in Hawaii. The average mill value of gray cement advanced $1.56 per ton to $21.73 and white cement increased $0.75 per ton to $46.06.

Published mill prices in the Engineering News-Record showed that December prices for bulk shipments ranged from a low of $21.60 per ton in Independence, Kans., to a high of $32.00 per ton in Waianae, Hawaii. Bagged cement prices for these areas were $25.40 and $34.40, respectively. Most prices were subject to cash discounts. Base prices for portland cement f.o.b. city were reported monthly in the Engineering News-Record for 20 cities across the United States. The December 1973 average for bulk cement was $26.76 per ton compared with $25.25 per ton in December 1972. In the 20-city survey, bulk prices ranged from a low of $23.00 per ton in Pittsburgh, Pa., to a high of $33.40 per ton in Denver, Colo. Masonry cement in bags averaged $32.37 per ton in December 1973 and ranged from $25.40 per ton in Detroit, Mich., to $37.00 per ton in Kansas City, Mo.

Rising costs of labor and fuel at cement plants continued to outpace selling prices in effect under the Economic Stabilization Act. When Phase II ended in January, the CLC granted modest price increases which were cost justified and fully documented by the applicant. The relatively modest price adjustments permitted within phase III guidelines resulted in some restoration of optimism in the industry. A significant event occurred November 27, when the CLC exempted the cement industry from wage and price controls. The decontrol action was

[2] Mill value is the actual value of sales to customers, f.o.b. plant; less all discounts and allowances; less all freight charges to customer; less all freight charges from producing plant to distribution terminal, if any; less total cost of operating terminal, if any; less cost of paper bags and pallets.

Table 13.—Portland cement shipped by plants in the United States, by type[1]

(Thousand short tons and thousand dollars)

Type	1972			1973		
	Quantity	Value	Average per ton	Quantity	Value	Average per ton
General use and moderate heat (types I and II)	75,452	1,512,214	$20.04	79,567	1,722,097	$21.64
High-early-strength (type III)	2,827	61,508	21.76	2,877	66,352	23.06
Sulfate-resisting (type V)	581	11,672	20.09	687	14,985	21.81
Oil-well	671	14,626	21.80	654	14,473	22.13
White	459	20,795	45.31	512	23,585	46.06
Portland-slag and portland pozzolan	438	8,412	19.21	1,021	22,103	21.65
Expansive	177	5,213	29.45	129	3,772	29.24
Miscellaneous [2]	827	19,341	23.39	952	22,910	24.07
Total or average	81,432	[3] 1,653,779	20.31	86,399	1,890,277	21.88

[1] Includes Puerto Rico.
[2] Includes type IV, waterproof cements.
[3] Data does not add to total shown because of independent rounding.

Table 14.—Average mill value in bulk of cement in the United States, by year[1]

(Per short ton)

Year	Portland cement	Slag cement	Prepared masonry cement [2]	All classes of cement
1969	$17.04	$20.44	$21.22	[3] $17.18
1970	17.69	W	22.68	17.88
1971	18.74	W	25.28	19.01
1972	20.31	W	26.52	20.59
1973	21.88	W	29.43	22.22

W Withheld to avoid disclosing individual company confidential data.
[1] Includes Puerto Rico.
[2] Includes masonry cements made at portland, natural, and slag cement plants.
[3] Includes slag cement.

designed to make cement price adjustments possible to the extent allowed by competitive forces, to offset increased operating costs, and to provide an adequate return on investments to make plant improvements and new capacity economically feasible.

FOREIGN TRADE

Exports of cement from the United States totaled 325,000 tons to attain the highest level since 1956 and reversed the decline which began in 1971. More than 90% of the total exports was marketed in only five countries—Canada, Mexico, Netherlands Antilles, Leeward and Windward Islands, and the Dominican Republic.

The cement industry imported cement and clinker at a recordbreaking level to supplement production and to relieve the strain on available capacity. Imports continued escalating for the sixth consecutive year, rising 36%, from 4,911,000 tons in 1972 to 6,683,000 tons in 1973, setting another alltime high. Imports, economically logical only in areas bordering points of entry, were most significant in Florida. More than 2,363,000 tons, or 35% of the total imports, entered through two customs districts, Tampa and Miami, in Florida.

Canada continued to be the principal foreign source of cement, supplying 42% of the imported cement and clinker, followed by United Kingdom with 17%, Bahamas with 14%, Norway with 10%, Spain with 5%, France with 5%, and Mexico with 4%. The combined imports from nine other countries accounted for the remaining 3%.

Total imports exceeded the cement manufactured in each individual State except for California, Pennsylvania, and Texas and were 676,000 tons more than was produced in Michigan, the 4th State in rank. Clinker comprised 41% of the total imports in 1973 compared with 34% in 1972. Nineteen plants were operating on imported clinker—six in Texas, three in Michigan, two each in Florida and South Carolina, and one each in Maine, New York, Pennsylvania, Virginia, Washington, and Wisconsin. Four of the plants used imported clinker exclusively to produce cement.

Imports appeared to be at their peak and could trend downward when present contracts expire. One foreign cement producer already was unable to supply substantial quantities of cement for Gulf Coast markets. Other indications were: Foreign countries continued to absorb more of their production and placed stricter controls on exports; several foreign companies indicated that they did not intend to expand plant facilities to meet growing demands in the United States; and carriers may find it difficult to obtain adequate ship fuel to transport cement and clinker.

Table 15.—U.S. exports of hydraulic cement, by country

Country	1971		1972		1973	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Austria	309	$34	168	$25	85	$18
Australia	1,205	60	282	25	554	27
Bahamas	2,467	96	2,722	181	1,514	94
Belgium-Luxembourg	917	54	542	28	98	24
Bermuda	682	40	293	25	269	20
Brazil	849	42	528	17	381	20
Canada	58,152	1,351	57,862	1,729	168,182	3,635
Chad	--	--	--	--	564	26
Chile	396	46	1,018	66	707	42
Costa Rica	224	6	512	16	646	28
Dominican Republic	227	40	810	34	16,045	269
Ecuador	604	37	1,126	53	266	12
Ethiopia	61	2	103	6	564	29
France	447	21	116	15	436	30
French West Indies	7,719	71	76	3	966	11
Germany, West	541	112	444	84	374	60
Guatemala	208	26	--	--	347	20
Honduras	190	13	357	16	546	28
Indonesia	515	26	86	5	1,200	86
Iran	228	(1)	336	13	3,081	149
Ireland	24	1	168	13	232	22
Italy	242	9	483	32	424	35
Jamaica	591	37	409	24	1,272	54
Japan	3,704	299	1,360	246	2,840	444
Korea, Republic of	25	(1)	106	5	318	33
Kuwait	161	6	98	2	260	7
Leeward and Windward Islands	12,709	130	9,669	100	17,173	174
Malagasy	2	14	--	--	475	23
Mauritania	--	--	--	--	475	21
Mexico	4,001	355	5,036	316	68,391	2,355
Netherlands Antilles	5,935	64	7,970	81	23,601	249
New Guinea	--	--	--	--	1,140	51
Nicaragua	626	24	58	6	130	5
Norway	633	23	409	20	262	7
Oman [2]	--	--	--	--	487	53
Pakistan	30	4	11	9	1,425	64
Panama	19	5	100	14	238	25
Peru	124	14	30	1	584	32
Philippines	301	30	174	15	207	35
Saudi Arabia	271	29	402	33	1,201	67
Singapore	29	6	90	19	299	30
South Africa, Republic of	93	2	66	18	140	19
Spain	52	12	195	20	198	32
Sweden	136	17	352	26	37	5
Switzerland	453	41	932	72	587	81
Taiwan	486	60	204	9	193	23
Trinidad and Tobago	25	8	383	16	365	22
Trust Territory of the Pacific Islands	--	--	376	(1)	905	38
Turkey	169	24	539	15	109	3
United Kingdom	249	22	431	28	436	54
Venezuela	285	15	175	19	1,298	113
Yugoslavia	125	27	29	15	93	20
Other	2,125	108	3,253	197	2,120	156
Total	109,566	3,463	100,889	3,712	324,740	8,980

[1] Less than ½ unit.
[2] Prior to January 1972 part of Arab Peninsula States.

Table 16.—U.S. imports for consumption of cement, by year [1]

(Thousand short tons and thousand dollars)

Year	Roman, portland, and other hydraulic cement		Hydraulic cement clinker		White nonstaining portland cement		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1971	2,327	35,681	728	7,610	33	1,057	3,088	44,348
1972	3,192	51,115	1,691	19,672	28	970	4,911	71,757
1973	3,911	67,406	2,743	35,501	29	1,177	6,683	104,084

[1] Includes Puerto Rico.

Table 17.—U.S. imports for consumption of hydraulic and clinker cement, by customs district and by country

(Thousand short tons and thousand dollars)

Customs district and country	1972 Quantity	1972 Value	1973 Quantity	1973 Value
Anchorage:				
Canada	57	1,183	54	1,107
Japan	(1)	2	(1)	1
Total	57	1,185	54	1,108
Baltimore: France	2	24	--	--
Boston:				
Belgium-Luxembourg	(1)	(1)	(1)	22
Canada	(1)	1	1	22
Total	(1)	1	1	44
Buffalo: Canada	500	6,919	677	9,735
Charleston: United Kingdom	219	2,503	273	3,617
Chicago:				
Canada	44	704	70	1,050
Germany, West	--	--	(1)	1
Spain	5	209	--	--
Total	49	913	70	1,051
Cleveland: Canada	--	--	(1)	134
Detroit:				
Canada	300	3,081	477	5,591
Spain	86	1,189	173	2,747
Sweden	38	360	--	--
Turkey	14	209	--	--
Total	438	4,839	650	8,338
Duluth: Canada	--	--	102	1,327
El Paso:				
Guatemala	--	--	(1)	4
Mexico	26	499	35	658
Total	26	499	35	662
Galveston:				
Denmark	12	148	--	--
Germany, West	--	--	(1)	3
United Kingdom	54	914	103	1,521
Total	66	1,062	103	1,524
Great Falls: Canada	3	64	2	57
Honolulu: Japan	1	13	1	13
Houston: United Kingdom	48	492	169	2,005
Laredo: Mexico	(1)	9	1	12
Los Angeles:				
Germany, West	(1)	10	(1)	16
Spain	--	--	1	55
Taiwan	(1)	1	--	--
United Kingdom	1	52	--	--
Total	1	63	1	71
Miami:				
Bahamas	257	4,147	224	4,053
Belgium-Luxembourg	1	27	2	73
Canada	55	644	222	2,691
Honduras	3	87	5	96
Italy	--	--	42	225
Mexico	67	837	30	461
Norway	139	1,389	238	4,671
Peru	4	62	--	--
Spain	--	--	1	180
Sweden	--	--	41	817
Turkey	11	86	--	--
United Kingdom	105	1,474	548	7,577
Total	642	8,753	1,353	20,844
Milwaukee: Canada	71	838	64	1,428
New Orleans: United Kingdom	1	31	--	--
New York City:				
Canada	--	--	(1)	(1)
Germany, West	--	--	(1)	4
Norway	462	7,099	438	6,095
Total	462	7,099	438	6,099
Nogales: Mexico	--	--	(1)	1
Norfolk:				
Bahamas	172	3,164	153	3,154
France	230	2,846	302	4,787
Italy	(1)	11	--	--
Spain	19	213	42	501
United Kingdom	--	--	46	595
Total	421	6,234	543	9,037
Ogdensburg:				
Canada	298	5,220	320	5,853
Panama	(1)	4	--	--
Total	298	5,224	320	5,853
Pembina:				
Canada	99	1,981	163	3,220
United Kingdom	--	--	(1)	1
Total	99	1,981	163	3,221
Philadelphia:				
Canada	40	540	--	--
Germany:				
East	(1)	6	--	--
West	5	454	4	416
Spain	21	174	--	--
Yugoslavia	3	139	2	90
Total	69	1,313	6	506
Portland, Maine: Canada	63	821	19	423
St. Albans:				
Canada	112	2,639	165	3,500
United Kingdom	--	--	(1)	1
Total	112	2,639	165	3,501
San Juan:				
Belgium-Luxembourg	13	538	13	611
Colombia	18	200	--	--
Denmark	5	183	--	--
France	(1)	18	(1)	11
Honduras	3	41	--	--
Spain	13	216	26	600
Venezuela	8	111	--	--
Total	60	1,307	39	1,222
Savannah: Spain	--	--	88	1,500
Seattle:				
Canada	361	4,533	336	3,982
United Kingdom	(1)	9	--	--
Total	361	4,542	336	3,982
Tampa:				
Bahamas	526	8,451	568	9,729
Belgium-Luxembourg	4	105	3	106
Canada	97	1,265	107	1,679
Denmark	4	55	--	--
Germany, West	--	--	29	376
Honduras	14	271	16	326
Mexico	197	2,242	208	3,214
Spain	--	--	30	540
United Kingdom	--	--	10	297
Venezuela	--	--	40	502
Total	842	12,389	1,011	16,769
Grand total	4,911	71,757	[2]6,683	104,084

[1] Less than ½ unit.
[2] Data does not add to total shown because of independent rounding.

Table 18.—U.S. imports for consumption of hydraulic and clinker cement, by country
(Thousand short tons and thousand dollars)

Country	1972		1973	
	Quantity	Value	Quantity	Value
Bahamas	955	15,762	945	16,936
Belgium-Luxembourg	18	670	18	812
Canada	2,100	30,433	2,779	41,799
Colombia	18	200	--	--
Denmark	21	386	--	--
France	233	2,888	302	4,798
Germany:				
East	(1)	6	--	--
West	5	464	33	816
Guatemala	--	--	(1)	4
Honduras	20	399	21	422
Italy	(1)	11	42	225
Japan	(1)	15	1	14
Mexico	290	3,587	273	4,346
Norway	601	8,488	676	10,766
Panama	(1)	4	--	--
Peru	4	62	--	--
Spain	144	2,001	361	6,128
Sweden	38	360	41	817
Taiwan	(1)	1	--	--
Turkey	25	295	--	--
United Kingdom	428	5,475	1,149	15,614
Venezuela	8	111	40	502
Yugoslavia	3	139	2	90
Total	4,911	71,757	6,683	104,084

[1] Less than ½ unit.

WORLD REVIEW

Increased costs of energy, wages, and transportation, plus the deterioration in profitability needed to maintain full utilization of production capacities were cause for concern by those manufacturers already confronted by the increased strain on available capacity.

In 1973, the European countries belonging to the European Cement Association (CEMBUREAU) put into operation at existing plants a total of 15 new kilns with a combined annual capacity of 8.5 million tons and started production at seven new plants with a total annual capacity of 4.1 million tons. Twenty-seven plant expansions and five new plants under construction will increase annual clinker production capacity by 20.3 million tons when completed in 1974.

Austria.—Gmunder Portlandzementfabrik Hans Hatschek A.G. and Schretter & Cie. each placed a new kiln into operation. The addition of these two kilns with a combined annual capacity of 680,000 tons, and the phasing out of five kilns with a combined capacity of 470,000 tons resulted in a net increase of 210,000 tons for the cement industry.

Belgium.—The expansion and modernization of the Obourg plant by Ciments d'Obourg S.A. (CBR), which includes a new 3,000-ton-per-day kiln and a 250-ton-per-hour grinding plant, is scheduled for completion late in 1975. A new 550,000-ton slag cement plant under construction by CBR at Gand is expected to be operational in 1974.

Brazil.—The new cement plant being constructed at Pedro Leopoldo in Minas Gerais by Cimento Nacional de Mines S.A. is expected to be operational late in 1974. The new plant will be equipped with a dry kiln with a 4-stage heat exchanger and will have an annual capacity in excess of 1 million tons.

Canada.—Lake Ontario Cement Ltd. completed the first phase of an expansion program at its Pitcon, Ontario, cement plant with the installation of two roller mills. The company is proceeding with phase two of the program and will install an 850,000-ton-per-year kiln system which will double clinker capacity of the existing plant. The latest technical developments available are to be built into the new kiln system to insure maximum production at minimum cost.

Genstar Ltd. acquired Miron Co. Ltd. of Montreal late in 1973. The acquisition of Miron Co. Ltd., with its more than 1 million tons of cement production capacity, makes Genstar Ltd. the second largest cement producer in Canada. A computerized central control system was installed at the company's Edmonton plant; modifications were made at the Bamberton plant to improve fuel efficiency; and work was underway to winterize the Winnipeg plant to allow operations to continue over a longer period of time each year.

The largest grinding mill of its type in the world, 18 feet in diameter by 72 feet in length, with a rating of 6,500 kilowatts was put into service by St. Lawrence Cement Co. at its Mississauga plant at Clarkson, Ontario.

Colombia.—Cementos Boyacá S.A. was constructing a new 100-ton-per-hour grinding mill at its plant near Bogotá. The modernization program also includes greater storage capacity and improvements in quarry and distribution facilities. The program is expected to be completed at the end of 1974.

Costa Rica.—Industria Nacional de Cemento S.A. completed the first phase of its expansion program at the Cartago plant and was rapidly proceeding with the second phase of the program. Under phase two, the company will reactivate and convert the wet process kiln to the dry process, install a new electrostatic precipitator, and construct a new raw grinding mill with a capacity of 100 tons per hour. Completion of the expansion program in 1974 will raise the plant's daily capacity of 1,300 tons.

Finland.—Paraisten Kalkkivuori Oy plans to install a new 550,000-ton-per-year coal-fired kiln at its Pargas plant.

France.—Output rose 2% in spite of the longest strike in the history of the French cement industry. Cement production was curtailed from November 16 to December 18. France remained the leading cement exporter of the CEMBUREAU, exporting 2.3 million tons.

The overall production capacity of the newly created Ciments d'Origny S.A. group (formerly Ciments d'Origny-Desvroise with three plants and S.A. des Chaux et Ciments Portland du Haut-Rhin with one plant) and its affiliated companies totals 4.4 million tons per year. Of this, 2.4 million tons was from the four Ciments d'Origny S.A. plants; 880,000 tons from the two Ciments de Champagnole plants; 770,000 tons from the Biache Saint Vaast plant of Ciments de Biache; and 330,000 tons from the Le Boucau plant of Ciments de l'Adour. A new 1,500-ton-per-day kiln being constructed by Ciments d'Origny at its Lumbres plant is expected to increase the annual capacity of the Origny group from 4.4 to 4.9 million tons.

Ciments Français began operating a new dry process kiln with an annual capacity of 360,000 tons at its Beffes plant and expects a 1-million-ton kiln now under construction at its Couvrot plant to begin operation in 1974.

Germany, West.—A new 3,300-ton-per-day kiln was put in service by Alsen-Breitenburg Zement-und Kalkwerke, G.m.b.H., at its Lägerdorf plant. Nordcement A.G. was unable to achieve continuous operation of a new kiln at its Alemannia plant at Höver due to unexpected technical difficulties. When the new facilities are fully operational, they will be capable of producing 1 million tons of cement annually.

Each of the following cement manufacturers completed installation of a new kiln: Georg Behringer Portlandzement und Kalkwerke; Portland-Zementwerke Heidelberg A.G.; E. Schwenk, Zement und Steinwerke; and Portlandzementwerk Wittekind Hugo Miebach Söhne.

Greece.—The acquisition of Hellenic Cement Co. in December 1972 and the completion of its new 700,000-ton plant at Drepanon, Patras, in June 1973 raised the Titan Cement Co.'s total annual capacity to 3.4 million tons. Halyps S.A. delayed completion of the new kiln at its Skaramanga plant until the end of 1974. Chalkis Cement Co. continued construction on its third 1-million-ton unit at Mikro Vathy, Avlidos. Basil B. Katsiapis received government approval to erect a 500,000-ton-per-year plant on the Island of Crete. Failure to obtain a license resulted in the cancellation of a joint venture by General Cement Co., Titan Cement Co., and Chalkis Cement Co. to build a 600,000-ton-per-year plant on Crete.

Indonesia.—Construction was started on the $35 million P.T. Semen Cibinong cement plant. The plant was to have a dry-process kiln with a suspension preheater and when completed in 1975, it would have an annual capacity of 550,000 tons. The company plans to more than double this capacity at some later date.

Iran.—Asia Cement Co., Teheran, authorized "Holderbank" Management and Consulting Ltd. to undertake the engineering work on a new 3-million-ton-per-year cement plant.

Israel.—Acceleration in consumption and difficulties in handling a greater volume of cement imports created serious problems for the cement industry. Israel Portland Cement Works "Nesher" Ltd., the only cement manufacturer in Israel, with plants at Haifa, Ramla and Bet Shemesh, was able to supply only 60% of the domestic requirements for cement. The rehabilitated Bet Shemesh plant purchased in 1972 was producing cement from imported clinker. The plant's maximum output of 600,000 tons is expected to be attained early in 1974. A new bulk cement unloading facility capable of handling 60 tons of cement per hour or 15,000 tons per month was erected at the port of Ashdod. A second unloading facility was expected to be installed at Ashdod and an order has been placed for one to be installed at Haifa. Solel Bonek, in joint ownership with Israel Corp. Investment Co., was given the option to construct a new cement plant at Mizpe Ramon, Negev.

Japan.—Ryukyu Cement Co. Ltd. completed a $2.3 million expansion program in Okinawa and increased productive capacity 18%, to 530,000 tons per year.

Lebanon.—Improved harbor facilities and installation of new loading equipment was completed by Société des Ciments Libanais at its Chekka plant. These improvements will enable the company to export cement considered to be in excess of domestic needs.

Mexico.—Cementos Apasco S.A. started construction of a new preheater kiln with a daily capacity of 2,000 tons at its Apaxco plant. The kiln was scheduled for operation late in 1974. Cementos Veracruz S.A. continued erection of a new 1,200-ton-per-day kiln at its Orizaba plant. The startup of the new kiln was scheduled for late 1974. Plant expansion was underway at Cementos Apasco, Cementos Veracruz, and Cementos Mexicanos.

Netherlands.—N.V. Eerste Nederlandse Cement Industrie (ENCI), in a joint venture with the Belgian CBR group, is constructing a new kiln at Lixhe with an annual capacity of 1 million tons. ENCI completed installation of a new 6,000-horsepower cement mill at its Rozenburg plant, increasing the annual capacity of the plant to 1 million tons of slag cement.

New Zealand.—New Zealand Cement Holdings Ltd. announced that it will add a third kiln with an annual capacity of 150,000 tons to its Westport plant. Both of the company's cement plants, at Westport and Barnside, operated at near capacity.

Nicaragua.—Production of portland cement went from 130,000 tons in 1972 to 194,000 tons in 1973, an increase of 49% to meet the demands created by the reconstruction of Managua after the December 23, 1972, earthquake. A new kiln being installed at the country's sole cement manufacturing plant at San Rafael del Sur is expected to raise the production capacity to 307,000 tons per year.

Norway.—Norcem, the sole manufacturer of cement in Norway, was established November 14, 1968, by merger of A/S Christiania Portland Cementfabrik, A/S Dalen Portland-Cementfabrik, and Nordland Portland Cementfabrik A/S. The combined output of the three plants, Slemmestad near Oslo (1.1 million tons), Dalen near Brevik (1.2 million tons), and Kjøprilk in Nordland (340,000 tons), provided Norcem with 2.7 million tons of cement annually. Norcem, with its fleet of 28 specially equipped bulk carriers, exported 676,000 tons of cement in 1973 to the United States.

Portugal.—Cia. Industrial do Cimento do Sul completed construction of its new 330,000-ton plant at Loulé. The new 550,000-ton plant under construction for Cia. de Cimentos do Norte at Souselas in northern Portugal is scheduled to begin production in 1974.

Spain.—Cementos Alba S.A. and Portland Valderrivas S.A. completed construction of their new cement plants. When full operation is attained, combined capacity of the two plants will be 1.5 million tons.

Switzerland.—The new 770,000-ton-per-year cement plant presently under construction by Cementfabrik Holderbank at Rekingen-Mellikon, Aargau, was scheduled to be operational early in 1975. Société des Chaux et Ciments de la Suisse Romande completed one phase of its modernization project at the Eclépens plant with the startup of a new raw mill and raw material installation early in the year. The next phase, which includes a new 1,500-ton-per-day dry-process kiln, was expected to be completed early in 1974. Bündner Cementwerke A.G. expects to have a new 1,600-ton-per-day dry-process kiln in operation at its Untervaz plant about mid-1974. A new kiln under construction for Wuerenlinger-Siggenthal is scheduled to be completed in 1974.

Thailand.—The 1973 cement production capacity was 4.3 million tons. Future expansion programs at the three cement companies in existence and the establishment of a fourth, approved by the Ministry of Industry, will raise the capacity to 6.8 million tons. Siam City Cement Co., Ltd., will increase capacity from 2,000 to 5,000 tons per day (approximately 1.5 million tons per year); however, no completion date has been announced. Jalaprathan Cement Co., Ltd., will boost capacity from the current rate of 1,500 to 3,000 tons daily at its plant at Amphu Cha-am, Petchaburi Province. Capacity at the firm's plant at Amphu Takli in Nakhon Sawan Province will be raised to 1,250 tons per day from the present 1,000 tons. Total annual capacity of the two plants will be about 1.3 million tons. While no completion date has been set for the Cha-am project, the Takli expansion is expected to be completed by the end of 1974. Siam Cement Co., Ltd., has ordered a new kiln and related equipment for its plant at Kaeng Khoi, Saraburi Province, to increase annual output 800,000 tons per year. The company's four plants after mid-1975 will have an aggregate plant capacity of 3.6 million tons per year. Thai Sathapana Co., Ltd., received permission from the Ministry of Industry in September 1973 to erect a 1,000-ton-per-day plant at Amphu Pak Tho in Ratchaburi Province. The plant, under construction, is due to go into production early in 1975.

Turkey.—Goltas Cimentos A.S. started production at its new plant at Isparta. The new plant under construction by Bolu Cimento Sanayii A.S. at Bolu will come into production in 1974. Five other plants under construction and scheduled for completion in 1975 are Unye at Ordu (620,000 tons); Mardin Cimento at Mardin (580,000 tons); Iskenderun at Hatay (550,000 tons); Kars Cimento at Kars (275,000 tons); and Akcimento at Mersin (in excess of 1 million tons).

Yemen Arab Republic.—The Soviet-built facility at Bajil was producing at 50% of its planned capacity of 50,000 tons of cement per year. There are plans to expand the Bajil plant and to build another cement plant to meet growing domestic needs.

TECHNOLOGY

Fuel requirements for kiln heat transfer systems vary widely among different clinker production systems as the following tabulation illustrates:

System	*10^6 Btu per ton of clinker*
Long dry kiln	5.00 to 7.80
Long wet kiln with chains	4.70 to 9.45
Long dry kiln with chains	3.90 to 6.10
Long dry kiln with waste heat boiler	4.95 to 6.10
Long dry kiln with internal crosses	3.90 to 5.85
Suspension preheater	2.85 to 4.45
Lepol grate preheater	3.55 to 3.85

Source: Kaiser Engineers.

Within each category, heat usage varies depending on a number of factors, the most important of which are the design of the systems, the degree of maintenance, the skill of the operator, and the composition of the raw materials. However, on the whole, the air suspension preheater consistently keeps the fuel expenditure much lower than any other type of system.

A method for disposing of oil slicks on coastal waters, rivers, and the like, using portland cement or other hydraulic cement was patented.[3] The method uses a finely ground cement, 1,000 to 12,000 square centimeters per gram, previously coated with hydropholic, natural, or synthetic oil. The coated cement is usually sprayed on the oil slick, forming oil-cement globules, which sink rapidly. The oil-cement globules are relatively stable, disintegrating only over a lengthy period of time, releasing small, noninjurious oil globules.

In accordance with the 1972–73 U.S.-Soviet Agreement on Exchanges and Cooperation in Scientific, Technical, Educational, Cultural, and Other Fields, signed April 11, 1972, four Soviet experts in the field of special cements and polymer concrete arrived in the United States in May 1973.

[3] Nutt, W. O. (assigned to Cement Marketing Co. Ltd.). British Pat. 1,282,411, July 19, 1972.

Table 19.—Hydraulic cement: World production, by country

(Thousand short tons)

Country	1971	1972	1973 [p]
North America:			
Bahamas	917	1,087	1,051
Canada (sold or used by producers)	9,066	9,976	10,884
Costa Rica	235	288	297
Cuba [e]	830	830	830
Dominican Republic	657	746	750
El Salvador	205	240	260
Guatemala	250	291	[e] 300
Haiti	79	89	[e] 90
Honduras	179	214	260
Jamaica	467	460	444
Mexico	[r] 8,113	9,482	10,788
Nicaragua	128	130	194
Panama	310	325	478
Trinidad and Tobago	282	316	290
United States (including Puerto Rico)	[r] 80,316	[r] 84,556	87,498
South America:			
Argentina	6,099	6,002	5,711
Bolivia	141	166	183
Brazil	10,806	12,545	14,709
Chile	1,508	1,548	[e] 1,200
Colombia	3,139	3,188	3,545
Ecuador	407	385	[e] 480
Paraguay	67	79	82
Peru	1,595	1,793	[e] 1,900
Surinam	54	[e] 110	[e] 130
Uruguay	504	513	577
Venezuela	3,086	3,287	4,740
Europe:			
Albania [e]	400	400	400
Austria	6,053	7,016	6,900
Belgium	7,640	7,815	7,762
Bulgaria	[r] 4,277	4,310	4,603
Czechoslovakia	8,770	8,868	9,238
Denmark	3,013	3,167	[e] 3,300
Finland	[r] 2,025	2,183	2,341
France	31,910	33,339	33,863
Germany, East	9,340	9,763	12,125
Germany, West	45,209	47,559	45,040
Greece	6,106	6,986	7,117
Hungary	2,989	3,273	3,757
Iceland	[r] 127	143	148
Ireland	1,657	1,619	1,852
Italy	[r] 35,052	36,882	39,961
Luxembourg	289	341	353
Netherlands	4,459	4,435	4,494
Norway	[r] 3,020	2,919	2,976
Poland	14,420	15,417	17,143
Portugal [1]	2,709	3,131	[e] 4,000
Romania	9,395	10,154	10,856
Spain (including Canary Islands)	[r] 18,916	21,495	24,511
Sweden	[r] 4,354	4,114	4,180
Switzerland	5,754	6,297	6,345
U.S.S.R	[r] 110,596	114,970	120,703
United Kingdom	[r] 19,508	19,894	22,037
Yugoslavia	5,461	6,339	6,841
Africa:			
Algeria	1,063	1,023	[e] 1,000
Angola	584	688	847
Cameroon	[r] 154	187	181
Cape Verde Islands	11	9	[e] 11
Egypt, Arab Republic of	4,322	4,213	3,995
Ethiopia	233	207	225
Ghana	585	454	[e] 500
Ivory Coast	551	643	661
Kenya	875	882	873
Liberia	100	100	[e] 100
Libya	79	[e] 90	[e] 90
Malagasy Republic	85	71	77
Malawi	69	82	98
Morocco	1,626	1,700	1,785
Mozambique	464	516	674
Niger	33	36	[e] 40
Nigeria	[r] 732	1,231	1,641
Rhodesia, Southern	616	690	[e] 720
Senegal	266	369	325
South Africa, Republic of	6,455	6,733	7,566
Sudan	[r] 208	175	229

See footnotes at end of table.

Table 19.—Hydraulic cement: World production, by country—Continued

(Thousand short tons)

Country	1971	1972	1973 p
Africa—Continued			
Tanzania	196	261	289
Tunisia	644	693	583
Uganda	r 226	183	e 165
Zaire	502	525	519
Zambia	519	534	454
Asia:			
Afghanistan [2]	100	109	e 110
Bangladesh	71	25	33
Burma	217	236	249
China, People's Republic of e	r 25,300	r 31,240	33,880
Cyprus	334	355	e 490
Hong Kong	564	450	485
India	16,418	17,306	16,535
Indonesia	r 537	657	915
Iran	3,142	3,968	e 4,410
Iraq	2,046	r e 2,100	e 2,000
Israel	1,549	1,703	1,336
Japan	r 65,515	73,120	86,007
Jordan	462	730	680
Khymer Republic	65	51	e 55
Korea, North e	r 5,300	r 5,800	6,400
Korea, Republic of	7,575	7,150	9,008
Lebanon	1,652	1,792	1,825
Malaysia	r 1,207	1,279	1,409
Mongolia	105	155	165
Pakistan	2,889	2,970	3,174
Philippines	r 3,436	3,200	4,474
Qatar e	280	280	280
Ryukyu Islands	e 280	e 280	([3])
Saudi Arabia	775	1,003	e 1,020
Singapore	676	1,112	e 1,200
Sri Lanka	425	422	465
Syrian Arab Republic	1,002	1,107	e 1,100
Taiwan	5,559	6,272	6,586
Thailand	3,063	3,739	4,128
Turkey	8,320	9,286	9,868
Vietnam, North e	550	280	550
Vietnam, South	290	268	292
Oceania:			
Australia	5,164	5,296	5,781
Fiji Islands	86	99	103
New Zealand	907	991	1,166
Total	r 679,948	r 728,601	780,344

e Estimate. p Preliminary. r Revised.

[1] Includes production from the Azores and Madeira Islands as follows in thousand short tons: 1971—None; 1972: Azores—17; Madeira—33; 1973: Azores—24 (estimated); Madeira—37 (estimated). The balance of output in each year was from continental Portugal.

[2] Year beginning March 21 of that stated.

[3] Included with Japan.

Chromium

By John L. Morning [1]

In 1973 worldwide demand for chromium brought increased production of chromite and chromium products worldwide. A record year for domestic stainless steel producers created a strong demand for chromium alloys. As a result, the domestic chromium alloy industry returned to the production levels of 1969 and 1970, imports of ferrochromium reached a new high, and domestic consumption of chromium alloys exceeded 500,000 tons for the first time.

Legislation and Government Programs.—The Office of Emergency Preparedness (OEP) on April 12 revised stockpile objectives for chromium materials as follows: Chemical-grade chromite, 8,400 tons; metallurgical-grade chromite, 444,710 tons; refractory-grade chromite, 54,000 tons; and high-carbon ferrochromium, 11,476 tons. A zero objective was established for low-carbon ferrochromium, ferrochromium-silicon, and chromium metal. At midyear, OEP was abolished and the Office of Preparedness under the General Services Administration (GSA) was established.

Government chromium stockpile material inventories are shown in table 2. Included in the inventories is material sold but unshipped. This includes chemical-grade chromite, 185,268 tons; metallurgical-grade chromite, 85,342 tons; and refractory-grade chromite, 135,339 tons. In addition, 191 tons of chromium metal was inventoried as undelivered sales.

GSA under various disposal programs offered for sale all three grades of chromite and chromium metal. Sales were as follows: Metallurgical-grade chromite, 39,931 tons; refractory-grade chromite, 191,000 tons; and chromium metal, 1,055 tons.

Deliveries of chromite from Government stockpiles from current or prior year sales contracts were as follows: Chemical-grade, 155,412 tons; metallurgical-grade, 56,586 tons; and refractory-grade, 62,433. In addition, delivery of 864 tons of chromium metal added to the domestic supply.

The Ferroalloys Association in early May sought relief against a high level of imports of chromium and manganese alloys by petitioning the Tariff Commission under Section 301 of the Trade Expansion Act of 1962. By late June, the worldwide steel boom had been initiated, order books were filled, and profits improved. The domestic ferroalloy producers then requested a suspension of the complaint.

The Environmental Protection Agency (EPA) proposed effluent limitation guidelines for existing sources, and standards of performance and pretreatment standards for new sources for the electroplating point source category.[2]

EPA also proposed rules for the ferroalloy manufacturing point source category and effluent limitation guidelines for existing sources; and standards of performance and pretreatment standards for new sources.[3]

The National Institute for Occupational Safety and Health (NIOSH) submitted criteria for recommended standards governing exposure to toluene diisocyanate or chromic acid and toluene. Chromic acid was defined as meaning chromium trioxide and solutions of chromium trioxide. The criteria document recommended that no worker be exposed to chromic acid in concentrations greater than 0.05 milligram per cubic meter of air determined as a time-weighted average, or a ceiling concentration greater than 0.1 milligram per cubic meter determined by sampling time of 15 minutes.

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[1] Physical scientist, Division of Ferrous Metals—Mineral Supply.
[2] Federal Register. V. 38, No. 193, Oct. 5, 1973, pp. 27694–27699.
[3] Federal Register. V. 38, No. 201, Oct. 18, 1973, pp. 29008–29018.

The Department of the Treasury revoked a finding (FR March 21, 1964) that the importation of chromic acid from Australia was injurious to the domestic industry.[4] With this action, the Department closed the case.

[4] Federal Register. V. 38, No. 37, Feb. 26, 1973, p. 5175.

Table 1.—Salient chromite statistics

(Thousand short tons)

	1969	1970	1971	1972	1973
United States:					
Exports	49	41	35	20	21
Reexports	150	73	145	57	34
Imports for consumption	1,106	1,405	1,299	r 1,056	931
Consumption	1,411	1,403	1,093	1,140	1,387
Stocks Dec. 31: Consumer	740	733	1,019	857	597
World: Production	5,865	6,672	r 7,093	6,977	7,507

r Revised.

Table 2.—U.S. Government chromium stockpile material inventories and objectives

(Thousand short tons)

	Objective	Inventory by program, Dec. 31, 1973			
		National stockpile	Defense Production Act	Supplemental stockpile	Total
Chromite, chemical-grade	8	529	--	224	753
Chromite, refractory-grade	54	932	--	174	1,106
Chromite, metallurgical-grade	444	2,266	901	323	3,490
Ferrochromium, high-carbon	11	126	--	277	403
Ferrochromium, low-carbon	--	128	--	191	319
Ferrochromium-silicon	--	26	--	33	59
Chromium metal	--	--	--	7	7

DOMESTIC PRODUCTION

Domestic mine production of chromite ceased in 1961 when the last Government Defense Production Act contract was phased out. However, the United States continued to be one of the world's leading chromite consumers in producing chromium alloys, refractories, and chemicals. The principal producers of these products were as follows:

Company	Plant
Metallurgical industry:	
Airco Alloys and Carbide Div., Air Reduction Co. Inc	Calvert City, Ky. Niagara Falls, N.Y. Charleston, S.C.
Chromium Mining & Smelting Corp	Woodstock, Tenn.
Foote Mineral Co	Vancoram, Ohio Graham, W.Va.
Interlake Inc	Beverly, Ohio
Ohio Ferro-Alloys Corp	Brilliant, Ohio
Shieldalloy Corp	Newfield, N.J.
Union Carbide Corp	Niagara Falls, N.Y. Marietta, Ohio Alloy, W.Va.
Refractory industry:	
Basic, Inc	Maple Grove, Ohio
Corhart Refractories Co., Inc	Louisville, Ky.
General Refractories Co	Baltimore, Md. Lehi, Utah
Harbison-Walker Refractories Co. (Div. of Dresser Industries, Inc.)	Hammond, Ind. Baltimore, Md.
Kaiser Aluminum & Chemical Corp	Moss Landing, Calif. Columbiana, Ohio
E.J. Lavino & Co. (Div. of IMC)	Plymouth Meeting, Pa.
North American Refractories Co	Womelsdorf, Pa.
Ohio Fire Brick Co	Jackson, Ohio
Chemical industry:	
Allied Chemical Corp	Baltimore, Md.
Diamond Shamrock Corp	Castle Haynes, N.C. Kearny, N.J.
PPG Industries, Inc	Corpus Christi, Tex.

CONSUMPTION AND USES

Domestic consumption of 1,387,000 tons of chromite ore and concentrate containing about 429,000 tons of chromium was 18% higher than in 1972. Of the total chromite consumed, the metallurgical industry used 66.3%, the refractory industry 18.8%, and the chemical industry 14.9%. The metallurgical industry consumed 920,000 tons of chromite containing 303,000 tons of chromium in producing 417,745 tons of chromium alloys and metal. About 67.6% of the metallurgical-grade ore had a chromium-to-iron ratio of 3:1 and over, 16.8% had a ratio between 2:1 and 3:1, and 15.6% had a ratio of less than 2:1.

Producers of chromite-bearing refractories consumed 261,000 tons of ore containing about 63,000 tons of chromium. The chemical industry consumed 206,000 tons of chromite containing about 64,000 tons of chromium in producing 159,000 tons of chemicals (sodium bichromate equivalent).

Chromium has a wide range of applications in three consuming industries. In the metallurgical industry its principal use is in stainless steel. Owing to a record year in stainless steel production, demand for chromium alloys was strong, especially during the last 9 months of the year. Stainless steel accounted for 73% of total chromium alloys consumed, an increase of over 100,000 tons compared with that of 1972. Consumption of alloys in most other end use categories increased significantly with the exception of carbon steel.

In the refractory industry, chromium was used in the form of chromite primarily for the manufacture of refractory bricks to line metallurgical furnaces. Consumption of chromite for refractory purposes increased 17% compared with that of 1972.

The chemical industry consumes chromite for manufacturing sodium or potassium dichromate, the base material for a wide range of chromium chemicals. Chromite consumption in this industry increased 9% compared with that of 1972.

Table 3.—Consumption of chromite and tenor of ore used by primary consumer groups in the United States

Year	Metallurgical industry		Refractory industry		Chemical industry		Total	
	Gross weight (thousand short tons)	Average Cr_2O_3 (Percent)	Gross weight (thousand short tons)	Average Cr_2O_3 (Percent)	Gross weight (thousand short tons)	Average Cr_2O_3 (Percent)	Gross weight (thousand short tons)	Average Cr_2O_3 (Percent)
1969	898	49.1	302	35.0	211	45.1	1,411	45.5
1970	912	48.0	278	35.9	213	45.3	1,403	45.2
1971	720	47.8	193	36.3	180	45.6	1,093	45.4
1972	727	47.9	224	35.9	189	45.7	1,140	45.2
1973	920	48.1	261	35.0	206	45.3	1,387	45.2

Table 4.—Production, shipments, and stocks of chromium ferroalloys and chromium metal

(Short tons)

Alloy	Production: Gross weight	Production: Chromium content	Shipments	Producer stocks Dec. 31
1972:				
Low-carbon ferrochromium	68,372	47,766	78,997	23,575
High-carbon ferrochromium	169,525	112,805	162,718	37,888
Ferrochromium-silicon	98,223	36,886	90,986	22,096
Other [1]	14,239	11,349	16,104	2,585
Total	350,359	208,806	348,805	86,144
1973:				
Low-carbon ferrochromium	86,958	60,917	103,444	9,343
High-carbon ferrochromium	234,102	158,550	251,954	20,475
Ferrochromium-silicon	78,992	29,071	88,921	7,177
Other [1]	17,693	11,505	18,040	2,046
Total	417,745	260,043	462,359	39,041

[1] Includes chromium briquets, chromium metal, exothermic chromium additives, and other miscellaneous chromium alloys.

Table 5.—U.S. consumption, by end uses, and consumer stocks of chromium ferroalloys and metal in 1973

(Short tons, gross weight)

End use	Low-carbon ferro-chromium	High-carbon ferro-chromium	Ferro-chromium-silicon	Other	Total
Steel:					
Carbon	1,057	2,300	504	387	4,248
Stainless and heat-resisting	117,842	177,970	77,366	231	373,409
Full alloy	16,553	45,493	4,945	4,482	71,473
High-strength low-alloy and electric	2,456	9,379	2,507	2,269	16,611
Tool	1,873	4,865	273	74	7,085
Cast irons	1,170	9,769	232	1,118	12,289
Superalloys	5,057	6,454	557	2,142	14,210
Alloys (excluding steels and superalloys):					
Welding and alloy hard-facing rods and materials	616	790	--	286	1,692
Other alloys [1]	1,236	1,363	22	2,475	5,096
Miscellaneous and unspecified	2,873	807	56	1,377	5,113
Total	150,733	259,190	86,462	[2] 14,841	511,226
Chromium content	102,444	168,539	34,755	9,904	315,642
Stocks Dec. 31, 1973	15,802	24,162	6,740	[3] 1,752	48,456

[1] Includes magnetic and nonferrous alloys.
[2] Includes 5,181 tons of chromium metal.
[3] Includes 698 tons of chromium metal.

STOCKS

Chromite stocks decreased significantly for the second successive year; however, the metallurgical industry accounted for virtually all of the decrease. Stocks in the metallurgical industry decreased nearly 44%, while stocks in the chemical and refractory industries were about the same as in 1972.

Owing to strong demand for chromium alloys, producer stocks decreased 55% as consumer stocks rose 77% compared with those of 1972.

Table 6.—Consumer stocks of chromite, Dec. 31

(Thousand short tons)

Industry	1969	1970	1971	1972	1973
Metallurgical	296	387	667	601	339
Refractory	301	235	233	160	154
Chemical	143	111	119	96	104
Total	740	733	1,019	857	597

Stocks of chromium chemicals (sodium bichromate equivalent) at producer plants decreased from 13,936 tons in 1972 to 6,858 tons in 1973.

PRICES

Despite vastly improved demand for chromite ore and chromium products, ore prices were generally down somewhat from their 1972 levels. Some ferrochrome prices, on the other hand, showed conspicuous advances. Imported ferrochrome also increased in price owing to dollar revaluations and increased demand.

Soviet metallurgical-grade ore continued to decline in price for the second straight year after a continuous 4-year rise that peaked in 1971. Midyear prices for Soviet ore with a 4:1 chromium-to-iron ratio decreased to \$37 to \$39 per metric ton, 48% Cr_2O_3 pricing basis, f.o.b. Soviet ports. Turkish 3:1 chromite was down to \$37 per long ton, 48% basis, f.o.b. Atlantic coast ports. In contrast to declining prices for Soviet and Turkish ores, South African chromite rose to $33 to $34 per long ton, f.o.b. Atlantic coast ports.

Domestic ferrochromium prices, which were eroded in 1972 owing to lack of demand and an influx of ferrochromium imports, increased in the second quarter of 1973. Further increases in price during the year were not permitted under the Goverment's economic stabilization program.

Selected chromium alloy prices published by Metals Week for December 28, 1973, follow:

Material	Cents per pound of chromium
High-carbon ferrochromium [1]	23.7
Charge chromium	22.0–23.0
Imported charge chromium	21.0–22.5
Low-carbon ferrochromium (0.25% carbon)	36.5
Low-carbon ferrochromium (0.05% carbon)	35.0
Imported low-carbon ferrochromium	34.0
	Cents per pound of product
Aluminothermic chromium metal	138
Electrolytic chromium metal	153

[1] 1972 price; 1 producer's price was 26.2 cents for 1973.

FOREIGN TRADE

Exports of chromite were about the same as in 1972, but reexports decreased 40% compared with those of 1972. Major exports were to Canada, 41%; Ireland, 31%; and Mexico, 18%; the balance went to seven other countries. Reexports were shipped to Mexico, 64%; Ireland, 19%; and Canada, 17%.

Ferrochromium exports increased 18% to 15,164 tons valued at $5.1 million. West Germany received 34%; Canada, 30%; the United Kingdom, 14% and 16 countries received the balance.

Chromium and chromium alloys (wrought and unwought) and waste and scrap exports increased to 388 tons valued at $556,000 from 200 tons in 1972.

Exports of pigment-grade chromium chemicals increased 50% compared with those of 1972, rising to 249 tons valued at $461,000. Canada received 38% of the shipments; Japan, 20%; and the United Kingdom, 16%; the balance went to 21 other countries. Non-pigment-grade chromium chemicals exported totaled 2,568 tons valued at $2,687,000, increasing 103% in quantity and 76% in value compared with those of 1972.

Exports of sodium chromate and dichromate more than tripled, rising to 12,341 tons valued at $3,374,000. Canada was the leading recipient of shipments with 35% of the total, followed by the Republic of Korea, 13%; Taiwan, 11%; and Japan, 10%. Thirty-two other countries also received shipments.

Despite a big year in the domestic consuming industries, imports of chromite decreased 12% compared with those of 1972. Imports from the U.S.S.R. and Southern Rhodesia decreased 44% and 53%, respectively, while imports from the Philippines, the Republic of South Africa, and Turkey increased 45%, 22%, and 36%, respectively.

Imports of ferrochromium set a record yearly high for the third year in a row as 155,541 tons valued at $35,175,000 was received. The Republic of South Africa (30%), Japan (25%), Sweden (14%), and Southern Rhodesia (11%) accounted for 80% of the low-carbon ferrochromium imports, whereas Southern Rhodesia (41%), the Republic of South Africa (37%), Finland (8%), and Brazil (6%) accounted for 92% of the high-carbon ferrochromium imports.

Ferrochromium-silicon imports were 55% higher than in 1972. Three countries supplied 13,037 tons valued at $3,127,000. Southern Rhodesia supplied 68%; the Republic of South Africa, 31%; and Sweden, 1%.

Chromium carbide imports of 308 tons valued at $882,000 were nearly double those of 1972. West Germany supplied 80% and the United Kingdom the balance.

Imports of chromium metal, unwrought and waste and scrap, increased to 2,690 tons valued at $6,080,000 from 1,894 tons valued at $3,791,000 in 1972. Of the nine countries supplying imports, the United Kingdom accounted for 59% and Japan for 33%.

Imports of chromium-containing pig-

Table 7.—U.S. exports and reexports of chromite ore and concentrates

(Thousand short tons and thousand dollars)

Year	Exports		Reexports	
	Quantity	Value	Quantity	Value
1971	35	2,094	145	6,081
1972	20	824	57	1,946
1973	21	789	34	989

Table 8.—U.S. imports for consumption of chromite, by grade and country

(Thousand short tons and thousand dollars)

Country	Not more than 40% Cr_2O_3			More than 40% but less than 46% Cr_2O_3			46% or more Cr_2O_3			Total		
	Gross weight	Cr_2O_3 content	Value	Gross weight	Cr_2O_3 content	Value	Gross weight	Cr_2O_3 content	Value	Gross weight	Cr_2O_3 content	Value
1972:												
Iran	--	--	--	14	6	346	--	--	--	14	6	346
Malagasy Republic	13	4	390	--	--	--	--	--	--	13	4	390
Pakistan	--	--	--	--	--	--	27	13	909	27	13	909
Philippines	122	39	2,835	--	--	--	9	4	201	131	43	3,036
Rhodesia, Southern	--	--	--	27	12	876	65	31	1,876	92	43	2,752
South Africa, Republic of	--	--	--	141	62	1,704	108	51	r 1,598	249	113	r 3,302
Turkey	r 27	r 11	r 642	13	6	368	56	34	r 1,804	96	r 51	r 2,814
U.S.S.R.	63	24	909	--	--	--	371	202	13,147	434	226	14,056
Total	r 225	r 78	r 4,776	195	86	3,294	636	335	r 19,535	r 1,056	r 499	r 27,605
1973:												
Guatemala	--	--	--	(1)	(1)	1	--	--	--	(1)	(1)	1
Pakistan	--	--	--	--	--	--	22	11	862	22	11	862
Philippines	186	62	4,263	--	--	--	4	3	100	190	65	4,363
Rhodesia, Southern	--	--	--	--	--	--	43	21	1,483	43	21	1,483
South Africa, Republic of	5	2	58	264	118	3,430	34	16	593	303	136	4,081
Turkey	11	4	319	37	16	1,063	83	39	2,827	131	59	4,209
U.S.S.R.	28	10	402	12	5	220	202	105	5,407	242	120	6,029
Total	230	78	5,042	313	139	4,714	388	195	11,272	931	412	21,028

r Revised.
[1] Less than ½ unit.

Table 9.—U.S. imports for consumption of ferrochromium, by country

Year and country	Low-carbon ferrochromium (less than 3% carbon)			High-carbon ferrochromium (3% or more carbon)		
	Gross weight (short tons)	Chromium content (short tons)	Value (thousands)	Gross weight (short tons)	Chromium content (short tons)	Value (thousands)
1972:						
Belgium-Luxembourg	39	28	$17	1,554	1,021	$237
Brazil	--	--	--	4,205	2,535	651
Canada	45	30	17	--	--	--
Finland	--	--	--	6,887	3,612	681
France	465	336	177	--	--	--
Germany, West	2,949	2,163	1,211	2,316	1,519	501
Italy	--	--	--	1,653	1,075	320
Japan	14,134	9,598	5,434	3,577	2,267	736
Netherlands	--	--	--	827	556	183
Norway	6,282	4,505	2,422	3,318	2,272	766
Rhodesia, Southern	3,578	2,581	1,403	11,835	8,075	1,910
South Africa, Republic of	23,095	14,406	5,955	30,890	17,113	4,361
Sweden	9,608	7,125	3,958	1,171	796	269
Turkey	6,882	4,703	2,312	--	--	--
Yugoslavia	1,117	774	416	4,844	3,176	651
Total	68,194	46,249	23,322	73,077	44,017	11,266
1973:						
Brazil	--	--	--	7,129	4,160	1,012
Canada	9	6	5	--	--	--
Finland	--	--	--	8,652	4,528	888
Germany, West	2,077	1,506	1,117	413	263	84
Japan	10,856	7,577	4,263	441	298	119
Norway	3,194	2,163	1,260	1,160	792	281
Rhodesia, Southern	6,321	4,505	2,508	47,190	32,166	8,041
South Africa, Republic of	13,218	8,745	4,385	41,360	23,451	6,448
Spain	--	--	--	1,385	944	302
Sweden	6,015	4,542	2,786	1,160	783	276
Turkey	1,654	1,180	598	--	--	--
Yugoslavia	--	--	--	3,307	2,149	802
Total	43,344	30,224	16,922	112,197	69,534	18,253

ments were as follows: Chrome green, 161 tons; chrome yellow, 4,492 tons; chromium oxide green, 915 tons; hydrated chromium oxide green, 10 tons; molybdenum orange, 5,031 tons; and zinc yellow, 1,347 tons. Total value was $5.6 million, 11% lower than in 1972. Chromium yellow accounted for 53% of the total value of these products. The leading suppliers were Japan, 42% of total value, and Canada, 22%.

Sodium chromate and dichromate imports totaled 1,031 tons valued at $209,000, a substantial decrease from the 5,748 tons imported in 1972. Japan supplied 84% of the imports and the Republic of South Africa the balance. In addition, 6 tons of potassium chromate and dichromate was received from West Germany.

WORLD REVIEW

Albania.—According to the head of the State Planning Commission, chromite production will be a future growth area. For the 5-year plan of 1971–75, chromite output was targeted at 992,000 tons in 1975. Chromite concentrate was first exported in 1972, and export sales were expected to double in 1973. The state agency, Exportal, controls sales to foreign markets.

Greece.—Chromite production in Greece primarily comes from two mines. Metallurgical ore (concentrate) was produced by the General Mineral Exploration and Mining Development Corp. (GEMEE) at the Skoumtsa mine in the Kozani area of Macedonia, while refractory ore was produced by the Scalistiri Group at Tsangli near Fársala in Thessaly. A full assessment of Greece's chromite resources has not been made, but exploration activity during the past few years increased estimated reserves to 6.5 million tons proven and 2 million tons possible. Chromite consumption in Greece, primarily refractory-grade ore, was used at a brick plant operated by the Scalistiri Group.

Table 10—Chromite: World production by country

(Thousand short tons)

Country [1]	1971	1972	1973 [p]
Albania	553	[r] [e] 630	720
Argentina	(2)	[e] (2)	[e] (2)
Brazil [e]	31	33	33
Colombia	1	[r] [e] (2)	13
Cuba [e]	22	22	22
Cyprus	[r] 46	26	[3] 33
Finland	123	107	[e] 130
Greece	[r] 16	24	[e] 24
India	288	325	295
Iran	194	198	[e] 200
Japan	35	27	26
Malagasy Republic	[r] 165	123	173
Pakistan	27	36	24
Philippines	[r] 474	385	640
Rhodesia, Southern [e]	[r] 600	[r] 600	600
South Africa, Republic of	1,812	1,635	1,818
Sudan	23	25	35
Turkey	[e] 665	[e] 710	617
U.S.S.R.[e]	1,980	2,040	2,100
Yugoslavia	38	31	4
Total	[r] 7,093	6,977	7,507

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition to the countries listed, Bulgaria, North Korea and North Vietnam also produce chromite, but available information is inadequate to permit estimation of output levels.

[2] Less than ½ unit.

[3] Exports.

India.—India's chromite production in 1972 increased nearly 13% compared with that of 1971. Exports, all to Japan for the fourth consecutive year, dropped by 33,547 tons to 62,218 tons. Ferrochromium output fell from 13,756 tons in 1971 to 1,422 tons. The country's principal ferrochromium producer, Ferroalloy Corp. Ltd., did not operate owing to poor marketing conditions; Industrial Corp. of Orissa, Ltd. ceased operating in June; three other producers operated intermittently to meet limited requirements.

Japan.—Japan's production of chromium alloys in 1971–72 reached 450,000 tons. Over one-half was charge chromium; 120,000 tons of low-carbon ferrochromium and 80,000 tons of ferrochromium-silicon were also produced. Demand for chromium alloys for stainless steel production in 1974 was projected at 760,000 tons.

Mozambique.—Interest was shown by Companhia Moçambicana de Minas S.A. (CONOCMIN) in the ultrabasic formation of Mount Achiza. Chromium and nickel minerals have been identified in the area.

Philippines.—Output of chromite increased 66% compared with that of 1972; 84% was classified as refractory-grade and 16% as metallurgical-grade. Exports of refractory-grade chromite totaled 492,143 tons. The United States received 55%; Japan 15%, and the United Kingdom 11%. The balance was shipped to nine other countries. Japan received all of the 105,466 tons of metallurgical-grade chromite exported.

Rhodesia, Southern.—United Nations economic sanctions, which were applied in 1966, brought retaliation by the Rhodesian Government in the form of an embargo on mining news, primarily production data. Firm production data has been unavailable since 1965. Estimated annual chromite production of 400,000 tons has been carried by the Bureau of Mines for several years, and numerous sources have indicated that the figure is too low. Rhodesian ferrochromium production capacity could utilize more than the estimated figure. Accordingly, the Bureau of Mines estimate has been increased to 600,000 tons annually for 1971–73.

South Africa, Republic of.—Chromite production in the Republic of South Africa totaled over 1.8 million tons, an 11% increase compared with 1972 output. Of the total, 729,000 tons was classified as less than 44% Cr_2O_3, 1,056,000 tons from 44% to 48% Cr_2O_3, and 33,000 tons as over 48% Cr_2O_3. Local sales of chromite accounted for 497,000 tons and exports for 1,205,000 tons.

Transvaal Consolidated Land Exploration Co., Ltd., reported record sales of chromite owing to South African and worldwide demand for chromite. The firm maintained its position as the largest single producer of chromium ore in the Republic, and further expansion programs at new and existing mines were being undertaken.

Development of a chromite mine of Lavino (S.A.) (Pty.) Ltd., Steelpoort, Eastern Transvaal, was initiated in 1955, and shipments began in 1957. One seam of chromite about 50 inches thick currently is being worked and ranges in depth below surface from 16 feet to about 300 feet. A crushing and screening plant produces six sizes of ore ranging from 4-inch lump to minus 30-mesh foundry sand. Mine capacity is about 260,000 tons annually. Shipments are made to Lourenço Marques for export or to the African Metals Corp. Ltd. Ferrometals plant at Witbank.

Turkey.—Etibank (a State Agency) planned to initiate construction of a facility at Elâziğ to produce 25,000 tons of ferrochromium annually. The plant will produce ferrochromium and ferrochromium-silicon. Japanese financing is involved in return for ferrochromium shipments.

TECHNOLOGY

The basic principles of chromite flotation were discussed, and a review of previous work was presented.[5]

In addition, the results of experimental studies on Albanian, Cuban, and Russian chromite were described. The authors concluded; (1) of the various ions that can be present in the pulp, aluminum ions have the greatest influence on the flotation behavior of chromite; (2) in anionic flotation of chromite, aluminum species cause depression in the pH range of 4.5 to 8 and activation between pH 10 and 12; (3) complex effects of the gangue minerals and soluble species in solution cause similar flotation behavior of chromium ore with anionic and cationic collectors; and (4) because of high acid consumption and unfavorable conditions in acid environments, flotation of chromium ores should be undertaken under alkaline conditions.

Showa Denko KK (Japan) announced plans to produce a reduced chromite pellet for use in stainless steel manufacture. The pellets, made from chromite concentrate, would be 80% reduced in a rotary kiln. Full-scale testing was scheduled for mid-1974.

The growth of argon-oxygen decarburization (AOD) process for the manufacture of stainless steel in 1973 continued worldwide, as at least eight new installations initiated operations. The combination of the AOD process with that of continuous casting (CC), together with a listing of AOD and CC worldwide installations, was published.[6] It can be expected that other stainless steel producers in the United States and worldwide will team up AOD and CC.

Nippon Steel Corp. produced stainless steel by employing a combination of the basic oxygen steelmaking process and the RH-OB process developed by Nippon. The RH-OB process utilizes oxygen for final decarburization in a vacuum degassing unit.

Researchers showed considerable interest in thermodynamic properties of chromium alloys.[7]

Constitution diagrams for chromium-iridium and for chromium-rhodium were published.[8]

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[5] Sobieraj, S., and J. Laskowski. Flotation of Chromite: 1—Early Research and Recent Trends; 2—Flotation of Chromite and Surface Properties of Spinel Minerals. Inst. Min. and Met. Trans. —Sec. C, v. 82, No. 85, December 1973, pp. C207–C213.

[6] Journal of Metals. AOD–CC Gives Crucible Competitive Lead. V. 104, No. 5, October 1973, pp. 30–45.

[7] DeLuca, J. P., and J. M. Leitnakec. Review of Thermodynamic Properties of the Cr-N System. J. Am. Ceram. Soc., v. 56, No. 3, March 1973, pp. 126–129.

Natesan, K., and T. F. Kassner. Thermodynamics of Carbon in Nickel, Iron-Nickel and Iron-Chromium-Nickel Alloys. Met. Trans., v. 4, No. 11, November 1973, pp. 2557–2566.

Mazandarany, F. N., and R. D. Pehlke ,Thermodynamic Properties of Solid Alloys of Chromium With Nickel and Iron. Met. Trans., v. 4, No. 9, September 1973, pp. 2067–2076.

Young, D. J., W. W. Smeltzer, and J. S. Kirkaldy. Nonstoichiometry and Thermodynamics of Chromium Sulfide. J. Electrochem. Soc., v. 120, No. 9, September 1973, pp. 1221–1224.

[8] Waterstrat, R. M., and R. C. Manuszewski. The Chromium-Iridium Constitution Diagram. J. Less-Common Metals., v. 32, No. 1, July 1973, pp. 79–89.

———. The Chromium-Rhodium Constitution Diagram. J. Less-Common Metals, v. 32, No. 3, September 1973, pp. 331–343.

Analytical determination of chromium and manganese in steel is tedious and time consuming. A rapid spectrophotometric procedure that proved satisfactory over a 3-year period was published.[9]

The reactions occurring during the anodic polarization of tinplate passivated cathodically in a dichromate solution (CDC tinplate) were ascertained. It was found that a large portion of the CDC passivation film consists of chromium in the metallic state.[10]

M & T Chemicals Inc. announced the development of a commercial process for single-layer microcracked chromium plating that provides brighter deposits and a reproducible fine crack pattern in a plating time of 4 to 6 minutes. The firm claims the process leads to less corrosion and cost-cutting for electroplaters. In many applications it can enable the plater to have the same protection of the base metal with less nickel, thereby allowing platers to increase productivity and cut plating costs.

Patent activity during the year concerned burden preparation and prereduction of ore for production of ferroalloy;[11] direct reduction of oxide ores;[12] silicon control in production of high-carbon ferrochromium;[13] methods for purifying low-carbon ferrochromium and production of chromium metal;[14] methods for production of chromium chemicals;[15] and methods for chromium electroplating.[16]

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[9] Bhuchar, V. M., and V. P. Kukreja. Rapid Spectrophotometric Determination of Chromium and Manganese in Steels. Metallurgia and Metal Forming, v. 40, No. 3, March 1973, p. 91.

[10] Rauch, S. E., Jr., and R. N. Stienbricker. A Study of Surface Chromium on Tinplate. J. Electrochem. Soc., v. 120, No. 6, June 1973, pp. 735–738.

[11] Baum, J. J. Direct Reduction Apparatus. U.S. Pat. 3,740,042, June 19, 1973.

[12] Fey, M. G., and G. A. Kemeny. Method of Direct Ore Reduction Using a Short Cap Arc Heater. U.S. Pat. 3,765,870, Oct. 16, 1973.

[13] Eda, S., H. Iwabuchi, K. Yamagishi, and K. Nakagawa (assigned to Nippon Kokan K. K.). Method of Controlling the Amount of Silicon Contained as an Impurity in High-Carbon Ferrochromium. U.S. Pat. 3,765,871, Oct. 16, 1973.

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Eisner, S. (assigned to Norton Co.). Crack Free Hard Chrome. U.S. Pat. 3,749,652, Aug. 7, 1973.

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Clays

By Sarkis G. Ampian [1]

Clays in one or more of the classification categories (kaolin, ball clay, fire clay, bentonite, fuller's earth, or common clay and shale) were produced in 47 States and Puerto Rico. Clay production was not reported in Alaska, the District of Columbia, Rhode Island, or Vermont. The States leading in output were Georgia, 7.7 million tons; Texas, 5.7 million tons; and Ohio, 4.7 million tons; followed in order by North Carolina, Pennsylvania, and Alabama. Georgia also led in total value of clay output with $160.4 million; Wyoming was second with $24.0 million. Compared with 1972 figures, clay production increased in 30 States and value increased in 34 States. Total quantity of clays sold or used by domestic producers in 1973 was approximately 8% higher than in 1972, and total value was approximately 17% higher. Both the total tonnage and value of clays produced were alltime highs. Modest increases in value per ton were reported for all clays in 1973 owing to increased labor, fuel, and material costs. The increasing shortage and costs of fuels were causing considerable concern among clay producers and clay product manufacturers. Industrywide efforts were made to both economize and obtain standby fuels for their requirements. The costs of environmental protection equipment and environmental restrictions, combined with the energy crisis, were beginning to adversely affect production during the last quarter of 1973.

Kaolin in 1973 accounted for only 9% of the total clay production but for 46% of the domestic clay and shale value.

Table 1.—Salient clay and clay products statistics in the United States [1]

(Thousand short tons and thousand dollars)

	1969	1970	1971	1972	1973
Domestic clays sold or used by producers	58,694	54,853	56,666	59,456	64,351
Value	$264,415	$267,912	$274,431	$303,022	$354,058
Exports	1,574	2,076	1,973	1,847	2,097
Value	$45,767	$66,116	$65,329	$66,216	$79,774
Imports for consumption	82	87	64	67	53
Value	$1,750	$1,802	$1,501	$1,309	$1,879
Clay refractories, shipments (value)	$257,507	$256,384	$236,563	$274,679	$323,479
Clay construction products, shipments (value)	$608,982	$554,431	$641,567	$722,236	$783,187

[1] Excludes Puerto Rico.

DOMESTIC PRODUCTION, PRICES, AND FOREIGN TRADE, BY TYPE OF CLAY

KAOLIN

Domestic production of kaolin in 1973 increased 13%, and the value increased 19%. The average unit value for all grades of kaolin in 1973 was $27.26 per ton, $1.51 higher than in 1972. Kaolin was produced at mines in 16 States. Two States, Georgia (75%) and South Carolina (13%), accounted for 88% of the total U.S. production in 1973, Arkansas ranked third, Alabama fourth, and Texas fifth. Output in 1973 de-

[1] Physical scientist, Division of Nonmetallic Minerals—Mineral Supply.

clined in California and increased in Alabama, Arkansas, Florida, Georgia, Idaho, Minnesota, Missouri, Nevada, North Carolina, Pennsylvania, South Carolina, Texas, and Utah. Indiana became a new producing State in 1973.

Kaolin is defined as a white, claylike material approximating the mineral kaolinite. It has a specific gravity of 2.6 and a fusion point of 1,785° C. The other kaolin-group minerals, such as halloysite and dickite, are encompassed.

During 1973 J. M. Huber Corp. began construction of one of the world's largest spray dryers at its Wren, Ga., facility. Spray dryers were also added by Engelhard Minerals & Chemicals Corp. at its McIntyre, Ga., operation, and by Anglo-American Clay Corp. at its Sandersville, Ga., plant. Anglo-American's spray dryer was part of a completed expansion program started in early 1972 to meet the increasing demand for its high-brightness paper-coating grades. Anglo-American and Union Camp Corp. were jointly exploring the latter's lands in Georgia for commercially valuable kaolin deposits. Allied Chemical Corp. purchased a large kaolin property in Wilkinson County, Ga. Horton International announced its intentions to produce air-floated kaolin from its deposits near Sandersville and also to custom grind for other kaolin producers.

The Georgia Senate, seeking to capitalize on the aluminum potential of the State's kaolin, resolved to offer $250,000 to the first person or firm to commercially produce alumina or aluminum chloride from Georgia's deposits. The resolution, which stipulates that at least 300,000 tons must be produced the first year, must be passed by the Georgia House of Representatives and approved by the public as a constitutional amendment.[2] Georgia's kaolin deposits are considered to be the world's largest.

Exports of kaolin, as reported by the U.S. Department of Commerce, increased from 668,000 short tons valued at $26.3 million in 1972 to 732,000 tons valued at $30.5 million in 1973. The tonnage and value of the kaolin exported in 1973 increased 10% and 16%, respectively, over that shipped in 1972. The unit value per ton increased $2.29. This increase in the unit value of the kaolin exported was attributed to the greater percentage of the higher quality paper-coating grades shipped.

Kaolin was exported to 56 countries. The recipients were Japan, 31%; Canada, 22%; West Germany, 20%; Italy, 11%; and the remaining countries, 16%. Generally, exports to all countries increased, except for those to the Netherlands, France, Brazil, and Italy, which decreased 95%, 54%, 33%, and 4%, respectively. The kaolin producers reported the end use for their exports as follows: Paper coating, 55%; paper filling, 4%; rubber, 8%; and others, including refractories, fiberglass, paint, and plastics, 33%.

Kaolin imports in 1973 reversed the downward trend reported for a number of years by increasing from 25,481 short tons valued at $736,000 in 1972 to 34,203 tons valued at $881,000. The United Kingdom supplied nearly 98%; Canada, nearly 2%; and two other countries, less than 0.5%.

Kaolin prices quoted in the trade journals in 1973 were unchanged from 1972. Chemical Marketing Reporter, December 31, 1973, quoted prices as follows:

Waterwashed, fully calcined, bulk carload lots, f.o.b. Georgia, per ton	$76.00
Partially calcined, same basis, per ton	69.00
Paper-grade, uncalcined, same basis, per ton:	
No. 1 coating	$40.00–41.00
No. 2 coating	32.00–33.00
No. 3 coating	31.00–32.00
Filler, general purpose, same basis, per ton	14.00
Delaminated, waterwashed, uncalcined, paint-grade, 1-micrometer average, same basis, per ton	67.00
Dry-ground, air-floated, soft, same basis, per ton	14.00
National Formulary, powder, 50-pound bags, 5,000-pound lots, works, per pound	0.0675
National Formulary, colloidal, 150-pound drums, works, per pound	0.1650

The average unit value reported by domestic kaolin producers was $27.26 per ton, an increase of $1.51 above the 1972 value.

BALL CLAY

Production and value reported for domestically mined ball clay in 1973 increased 14% and 20%, respectively. Tennessee mines provided 64% of the Nation's output, followed in order of output by Kentucky, Mississippi, Texas, Maryland, New York, and California. Production in Kentucky, Maryland, Mississippi, and Tennessee increased over that reported in 1972, while California production decreased.

Ball clay is defined as a plastic, white-firing clay used principally for bonding in ceramic ware. The clays are of sedimentary

[2] Chemical Engineering. Chementator. V. 81, No. 3, February 1974, p. 19.

origin and consist mainly of the clay mineral kaolinite and sericite micas.

In 1973 Old Hickory Clay Co. installed a fluidized-bed dryer at its Gleason, Tenn., plant. This fluidized-bed dryer, an industry first, was reportedly capable of operating at lower temperatures than the present rotary dryers, thereby eliminating the danger of calcining or overfiring which reduces the natural plasticity of ball clays. H. C. Spinks Clay Co. began constructing a drying and grinding facility scheduled for completion in 1974, at Gleason. This facility will both expand production of air-floated and mechanically dried clays and eliminate costly hauling from its Gleason area mines to other plants.

The average unit value for ball clay reported by domestic producers rose in 1973 to $16.88 per ton, an increase of $0.89 per

Table 2.—Clays sold or used by producers in the United States in 1973, by State[1]

State	Short tons							Total value
	Kaolin	Ball clay	Fire clay	Bentonite	Fuller's earth	Common clay and shale	Total	
Alabama	127,044	--	359,840	W	--	2,446,648	[2] 2,933,532	[2] $8,787,607
Arizona	5	--	W	35,067	--	82,241	[3] 117,313	[3] 459,074
Arkansas	W	--	--	--	--	1,445,790	[4] 1,445,790	[4] 1,411,558
California	26,251	W	119,364	49,682	W	2,526,158	2,723,339	6,853,260
Colorado	--	--	58,126	1,012	--	734,485	793,623	1,709,851
Connecticut	--	--	--	--	--	161,707	161,707	320,171
Delaware	--	--	--	--	--	14,747	14,747	8,848
Florida	27,955	--	--	--	419,168	691,570	1,138,693	13,717,798
Georgia	4,510,263	--	W	--	444,326	2,766,378	[3] 7,720,967	[3] 160,419,215
Hawaii	--	--	--	--	--	W	W	W
Idaho	W	--	W	W	--	11,116	42,088	226,683
Illinois	--	--	97,270	--	W	1,660,306	[5] 1,757,576	[5] 3,612,680
Indiana	W	--	W	--	--	1,393,483	1,436,420	2,567,814
Iowa	--	--	--	--	--	967,396	967,396	2,028,001
Kansas	--	--	--	--	--	1,169,264	1,169,264	1,489,564
Kentucky	--	W	142,556	--	--	940,316	[6] 1,082,872	[6] 1,961,325
Louisiana	--	--	--	--	--	978,523	978,523	1,329,396
Maine	--	--	--	--	--	40,773	40,773	74,418
Maryland	--	W	--	--	--	896,599	[6] 896,599	[6] 1,973,492
Massachusetts	--	--	--	--	--	217,053	217,053	404,472
Michigan	--	--	--	--	--	2,150,706	2,150,706	3,304,398
Minnesota	W	--	--	--	--	155,555	[4] 155,555	[4] 233,283
Mississippi	--	W	--	286,135	W	1,622,586	2,074,985	9,082,347
Missouri	82,745	--	829,484	74,000	--	1,564,697	2,550,926	11,626,350
Montana	--	--	W	176,586	--	42,337	[3] 218,923	[3] 1,298,134
Nebraska	--	--	--	--	--	158,468	158,468	285,761
Nevada	1,950	--	45	W	--	W	35,650	176,370
New Hampshire	--	--	--	--	--	43,350	43,350	63,575
New Jersey	--	--	26,403	--	--	156,915	183,318	665,796
New Mexico	--	--	W	--	--	87,808	[3] 87,808	[3] 169,455
New York	--	W	--	--	--	1,798,912	[6] 1,798,912	[6] 2,146,185
North Carolina	W	--	--	--	--	4,109,174	[4] 4,109,174	[4] 5,057,166
North Dakota	--	--	--	--	--	W	W	W
Ohio	--	--	1,095,474	--	--	3,636,309	4,731,783	12,456,223
Oklahoma	--	--	--	W	--	1,297,699	[2] 1,297,699	[2] 1,871,026
Oregon	--	--	--	875	--	166,703	167,578	290,745
Pennsylvania	W	--	891,744	--	--	2,083,444	[4] 2,975,188	[4] 16,664,182
Puerto Rico	--	--	--	--	--	463,621	463,621	473,195
South Carolina	754,969	--	--	--	W	1,495,514	[5] 2,250,483	[5] 12,876,561
South Dakota	--	--	--	W	--	200,511	[2] 200,511	[2] 181,156
Tennessee	--	487,625	--	--	W	1,231,226	[5] 1,718,851	[5] 9,082,994
Texas	W	W	87,484	84,620	W	5,329,859	5,667,260	13,114,642
Utah	W	--	5,300	4,880	2,870	229,580	[4] 242,630	[4] 770,990
Virginia	--	--	--	--	--	1,645,726	1,645,726	1,885,774
Washington	--	--	W	--	--	286,538	[3] 286,538	[3] 663,873
West Virginia	--	--	W	--	--	347,833	[3] 347,833	[3] 516,300
Wisconsin	--	--	--	--	--	1,770	1,770	3,186
Wyoming	--	--	--	2,106,369	--	236,148	2,342,517	24,043,092
Undistributed	462,297	279,087	354,893	253,316	272,069	87,648	[7] 1,268,301	[7] 16,173,349
Total	5,993,479	766,712	4,067,983	3,072,542	1,138,433	49,775,190	64,814,339	354,531,335

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Includes Puerto Rico.
[2] Excludes bentonite.
[3] Excludes fire clay.
[4] Excludes kaolin.
[5] Excludes fuller's earth.
[6] Excludes ball clay.
[7] Incomplete total; remainder included in State totals.

Table 3.—Kaolin sold or used by producers in the United States, by State

State	1972 Short tons	1972 Value	1973 Short tons	1973 Value
Alabama	112,152	$1,186,466	127,044	$1,365,601
Arizona	5	150	5	150
California	58,743	522,198	26,251	256,641
Florida	W	W	27,955	789,375
Georgia	3,966,443	120,495,819	4,510,263	144,726,059
Missouri	W	W	82,745	W
Nevada	W	W	1,950	50,700
Ohio	28,371	135,748	--	--
Oregon	133	670	--	--
Pennsylvania	54,983	613,167	W	W
South Carolina	681,086	8,997,932	754,969	10,353,682
Other States [1]	415,721	4,953,400	462,297	5,829,174
Total	5,317,637	136,905,550	5,993,479	163,371,382

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes Arkansas, Idaho, Indiana (1973), Minnesota, North Carolina, Texas, Utah, and data indicated by symbol W.

Table 4.—Kaolin sold or used by producers in the United States, by kind

Kind	1972 Short tons	1972 Value	1973 Short tons	1973 Value
Airfloat	1,307,066	$19,469,122	1,397,199	$21,963,180
Calcined	212,797	11,324,402	176,425	12,980,059
Delaminated	186,230	8,574,354	194,180	10,193,638
Unprocessed	872,785	9,297,150	1,230,823	16,623,207
Waterwashed	2,738,759	88,240,522	2,994,852	101,611,298
Total	5,317,637	136,905,550	5,993,479	163,371,382

Table 5.—Georgia kaolin sold or used by producers, by kind

Kind	1972 Short tons	1972 Value	1973 Short tons	1973 Value
Airfloat	788,023	$10,317,785	839,625	$11,629,755
Calcined	132,895	10,196,168	146,425	11,934,459
Delaminated	186,230	8,574,354	194,180	10,193,638
Unprocessed	217,527	4,832,833	421,905	10,981,783
Waterwashed	2,641,768	86,574,679	2,908,128	99,986,424
Total	3,966,443	120,495,819	4,510,263	144,726,059

Table 6.—Georgia kaolin sold or used by producers, by kind and use

(Short tons)

Use	1972				1973			
	Airfloat	Unprocessed	Waterwashed [1]	Total	Airfloat	Unprocessed	Waterwashed [1]	Total
Domestic:								
Adhesives	W	--	W	54,012	W	--	W	44,218
Alum (aluminum sulfate) and other chemicals	--	(2)	(2)	(2)	--	W	W	131,942
Animal feed	(2)	--	--	(2)	117	--	--	117
Brick, face	--	13,250	--	13,250	565	--	--	565
Catalysts (oil refining)	(2)	--	(2)	(2)	W	--	W	43,699
China/dinnerware	(2)	--	--	(2)	W	--	W	18,084
Crockery and other earthenware	19,995	--	--	19,995	3,556	--	--	3,556
Fiberglass	W	--	W	130,625	W	--	W	134,604
Firebrick, block, shapes	73,509	19,388	--	92,897	32,400	47,252	--	79,652
Floor and wall tile, ceramic	18,385	--	--	18,385	W	--	W	21,485
Grogs and crudes, refractory	(2)	(2)	--	(2)	W	W	--	153,179
Gypsum products	--	--	(2)	(2)	W	--	W	52,023
Paint	W	--	W	127,460	11,982	--	99,320	111,302
Paper coating	16,100	--	1,417,816	1,433,916	71,502	--	1,539,409	1,610,911

See footnotes at end of table.

Table 6.—Georgia kaolin sold or used by producers, by kind and use—Continued

(Short tons)

Use	1972 Air-float	1972 Unprocessed	1972 Water-washed[1]	1972 Total	1973 Air-float	1973 Unprocessed	1973 Water-washed[1]	1973 Total
Domestic—Continued								
Paper filling	256,903	--	500,784	757,687	182,570	--	630,474	813,044
Plastics	W	--	W	66,844	W	--	W	61,889
Pottery	W	--	W	10,765	W	--	W	9,650
Roofing granules	(2)	--	--	(2)	W	--	W	306
Rubber	122,553	--	20,842	143,395	95,208	--	17,619	112,827
Sanitary ware	W	--	W	111,318	119,920	--	40,945	160,865
Miscellaneous:								
Animal feed; caulking, putty, sealers; linoleum; pesticides and related products	5,520	--	--	5,520	--	--	--	--
Catalysts (oil refining); foundry sand; unknown uses	15,763	--	--	15,763	--	--	--	--
China/dinnerware; glazes, glass, enamels; roofing tile	21,012	--	--	21,012	--	--	--	--
Electrical porcelain; refractory grogs and crudes; roofing granules	53,381	--	--	53,381	--	--	--	--
Electrical porcelain; glazes, glass, enamels; high alumina refractories; linoleum; pesticides, and related products; unknown uses	--	--	--	--	67,279	--	--	67,279
Aluminum sulfate; flue linings; refractory grogs and crudes; unknown uses	--	126,162	--	126,162	--	--	--	--
Flue linings, portland cement	--	--	--	--	--	39,481	--	39,481
Catalysts (oil refining); chemical manufacturing; aluminum sulfate	--	--	41,842	41,842	--	--	--	--
Face brick; gypsum products; refractory mortar and cement	--	--	433	433	--	--	--	--
Fertilizers; ink; textiles	--	--	15,566	15,566	--	--	--	--
Medical, pharmaceutical, cosmetic; foundry sand; ceramic tile; unknown uses	--	--	22,081	22,081	--	--	--	--
Fertilizers; mineral oil filtering, clarifying, decolorizing; ink; medical, pharmaceutical, cosmetic; foundry sand; refractory mortar and cement; textiles; unknown uses	--	--	--	--	--	--	46,113	46,113
Undistributed	171,993	--	329,031	(3)	241,062	251,085	178,932	(3)
Total	775,114	158,800	2,348,395	3,282,309	826,161	337,818	2,552,812	3,716,791
Exports:								
Paint	--	--	23,395	23,395	--	--	18,916	18,916
Paper coating	--	--	361,431	361,431	8,464	--	471,495	479,959
Paper filling	1,834	--	181,632	183,466	--	--	35,085	35,085
Refractories	10,000	58,727	33	68,760	5,000	84,087	--	89,087
Rubber	1,075	--	3,109	4,184	--	--	3,681	3,681
Other	--	--	42,898	42,898	--	--	166,744	166,744
Total	12,909	58,727	612,498	684,134	13,464	84,087	695,921	793,472
Grand total	788,023	217,527	2,960,893	3,966,443	839,625	421,905	3,248,733	4,510,263

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

1 Includes calcined and delaminated.

2 Included in "Miscellaneous" uses.

3 "Undistributed" total included with total for each specific use.

Table 7.—South Carolina kaolin sold or used by producers, by kind and use

(Short tons)

Kind and use	1972	1973
Airfloat:		
Adhesives	19,405	20,435
Fertilizers	41,832	41,030
Firebrick, block, shapes	7,690	5,382
Pesticides and related products	23,191	21,104
Rubber	227,057	248,496
Exports [1]	61,095	71,650
Other uses [2]	58,926	91,148
Total	439,196	499,245
Unprocessed: Face brick; firebrick, block, shapes (1972); other (1973), total	241,890	255,724
Grand total	681,086	754,969

[1] Fertilizers and rubber.

[2] Includes animal feed; electrical porcelain (1973); fiberglass; fine china/dinnerware; ceramic floor and wall tile (1972); glazes, glass, and enamels (1973); gypsum products; paint; paper filling; plastics (1973); pottery; sanitary ware; and other uses.

ton. Chemical Marketing Reporter, December 31, 1973, listed ball clay prices unchanged from 1972 as follows:

Domestic, air-floated, bags, carload lots, Tennessee, per ton	$18.00–$22.00
Domestic, crushed, moisture-repellent, bulk, carload lots, Tennessee, per ton	8.00– 11.25
Imported, air-floated, bags, carload lots Atlantic ports, per ton	70.00
Imported, lump, bulk, Great Lakes, per ton	40.50

Ball clay exports in 1973 amounted to 114,000 short tons valued at $2.2 million, compared with 87,000 tons worth $1.7 million in 1972. Exports increased 31% over that shipped in 1972, while the value was nearly 30% higher. The unit value of ball clay exported in 1973 declined $0.14 per ton, from $19.41 in 1972 to $19.27. These shipments were made to 21 countries. The major recipients were Canada, 47%, and Mexico, 45%; 19 countries accounted for the remaining 8%.

FIRE CLAY

Fire clay sold or used by domestic producers in 1973 was reported at 4,067,983 short tons valued at $36.2 million. Fire clay is defined as detrital material, either plastic or rocklike, containing low percentages of iron oxide, lime, magnesia, and alkalies to enable the material to withstand temperatures of 1,500° C or higher. Fire clay is basically kaolinite but usually contains other materials such as diaspore, ball clay, bauxite clay, and shale. Fire clays commonly occur as underclay below coal seams and are generally used for refractories. Some fire clay was previously reported in other end uses.

Fire clay production was reported in 1973 from mines in 20 States. The first four States in rank, Ohio, Pennsylvania, Missouri, and Alabama, accounted for 78% of the total domestic output.

In 1973, A. P. Green Refractories Co. purchased the plants and properties of H. K. Porter Co., Inc., near Fulton, Mo., and Bessemer, Ala.

Exports of fire clay increased from 124,000 short tons worth $2.9 million in 1972 to 196,000 tons valued at $3.82 million in 1973. Fire clay exports rose 58% in tonnage and 32% in value. The price of exported fire clay declined by $3.94 to $19.49 per ton.

Fire clay was exported to 48 countries, with Canada and Mexico receiving 56% and 26%, respectively. No imports of fire clay were reported during 1973.

There are no price quotations in domestic journals for fire clay, but the per-ton value reported by producers ranged from $2 to about $9. The reported average unit value for fire clay produced in the United States increased 9%, from $8.15 per ton in 1972 to $8.89 in 1973.

BENTONITE

Bentonite production in 1973 increased 11% in tonnage and 19% in value over that of 1972. A general increase in domestic consumption, particularly in iron ore pelletizing, drilling mud, animal feed, and oil filtering uses, was noted along with an overall increase in exports.

Table 8.—Kaolin sold or used by producers in the United States, by kind and use

(Short tons)

Use	1972 Airfloat	1972 Un-processed	1972 Water-washed [1]	1972 Total	1973 Airfloat	1973 Un-processed	1973 Water-washed [1]	1973 Total
Domestic:								
Adhesives	W	--	W	73,417	52,587	--	12,066	64,653
Alum (aluminum sulfate) and other chemicals	--	27,471	83,534	111,005	--	198,917	28,863	227,780
Animal feed	W	133	W	9,452	10,159	--	4,840	14,999
Brick, face	W	284,507	W	285,268	565	381,754	300	382,619
Catalysts (oil refining)	W	36,880	W	67,990	W	W	W	89,337
Cement, portland	--	54,434	21,264	75,698	--	86,507	20,730	107,237
Ceramic—hobby	--	5	--	5	--	--	--	--
China/dinnerware	W	--	W	50,801	21,278	--	8,464	29,742
Crockery and other earthenware	19,995	--	--	19,995	3,623	--	--	3,623
Electrical porcelain	5,938	--	--	5,938	11,410	--	4,500	15,910
Fertilizers	W	--	W	75,969	41,376	--	30,902	72,278
Fiberglass	W	--	W	153,788	W	--	W	189,311
Firebrick, block, shapes	84,739	252,608	--	337,347	41,977	270,205	--	312,182
Floor and wall tile, ceramic	43,235	200	--	43,435	29,162	--	4,833	33,995
Glazes, glass, enamels	W	W	W	27,126	687	--	7,450	8,137
Grogs and crudes, refractory	W	W	--	153,541	W	W	--	153,179
Gypsum products	6,491	6,100	3,510	16,101	52,394	--	3,861	56,255
Paint	16,617	--	124,878	141,495	17,703	--	114,270	131,973
Paper coating	16,100	--	1,417,816	1,433,916	71,502	--	1,539,409	1,610,911
Paper filling	264,354	--	500,784	765,138	194,151	--	630,474	824,625
Pesticides and related products	25,306	--	3,136	28,442	W	--	W	28,750
Plastics	W	5,000	W	71,844	7,539	--	55,089	62,628
Pottery	13,355	W	W	23,743	12,474	--	2,676	15,150
Roofing granules	W	--	--	W	W	--	W	306
Rubber	349,661	--	26,438	376,099	343,759	--	22,939	366,698
Sanitary ware	86,437	--	59,616	146,053	137,778	1,702	41,636	181,116
Miscellaneous	26,112	8,898	40,929	75,939	68,238	18,107	49,756	136,101
Undistributed	274,559	137,822	240,683	(2)	188,431	189,544	82,908	(2)
Total	1,232,899	814,058	2,522,588	4,569,545	1,306,793	1,146,736	2,665,966	5,119,495
Exports:								
Ceramics	--	--	W	W	5,292	--	9,059	14,351
Chemical manufacturing	--	--	W	W	--	--	139	139
Paint	--	--	23,395	23,395	--	--	19,616	19,616
Paper coating	--	--	361,431	361,431	8,464	--	471,495	479,959
Paper filling	1,834	--	181,632	183,466	--	--	35,085	35,085
Refractories	10,123	58,727	33	68,883	5,000	84,087	120	89,207
Rubber	59,525	--	3,109	62,634	68,739	--	3,681	72,420
Other	2,685	--	45,598	48,283	2,911	--	160,296	163,207
Total	74,167	58,727	615,198	748,092	90,406	84,087	699,491	873,984
Grand total	1,307,066	872,785	3,137,786	5,317,637	1,397,199	1,230,823	3,365,457	5,993,479

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Includes calcined and delaminated.
[2] "Undistributed" total included with total for each specific use.

Table 9.—Ball clay sold or used by producers in the United States, by State

State	1972		1973	
	Short tons	Value	Short tons	Value
Tennessee	431,126	$6,444,986	487,625	$7,744,794
Other States [1]	244,159	4,350,539	279,087	5,193,960
Total	675,285	10,795,525	766,712	12,938,754

[1] Includes California, Indiana (1972), Kentucky, Maryland, Mississippi, New York, and Texas.

Table 10.—Fire clay sold or used by producers in the United States, by State [1]

State	1972		1973	
	Short tons	Value	Short tons	Value
Alabama	350,094	$2,862,973	359,840	$3,884,488
California	100,270	281,387	119,364	624,992
Colorado	54,294	206,158	58,126	224,662
Idaho	9,868	W	W	W
Illinois	106,003	661,752	97,270	609,253
Kentucky	81,094	517,775	142,556	920,961
Maryland	3,319	11,617	--	--
Missouri	894,174	5,512,204	829,484	7,562,661
Nevada	W	W	45	420
New Jersey	59,372	370,757	26,403	150,596
Ohio	803,493	5,127,052	1,095,474	6,326,240
Pennsylvania	768,688	9,809,806	891,744	11,070,983
Tennessee	21	42	--	--
Texas	88,821	684,400	87,484	689,200
Utah	3,764	21,790	5,300	32,000
Other States [2]	257,360	3,117,220	354,893	4,061,431
Total	3,580,635	29,184,933	4,067,983	36,157,887

W Withheld to avoid disclosing individual company confidential data; included wth "Other States."
[1] Refractory uses only.
[2] Includes Arizona, Georgia, Indiana, Montana, New Mexico, Washington, West Virginia, and data indicated by symbol W.

Bentonite was produced in 15 States. Increased bentonite production was reported for all States except Montana, Nevada, Texas, Mississippi, Oklahoma, Oregon, and South Dakota.

Generally, the high-swelling or sodium bentonites are produced chiefly in Wyoming, Montana, and South Dakota. The calcium or low-swelling bentonites are produced in the other States.

A new production facility scheduled for completion in 1974 was begun in Worland, Wyo., by Black Hills Bentonite Co. The facility will substantially increase Black Hills' overall production capacity. Industry-wide improvements were made in environmental controls systems and in automating, bagging, and handling procedures.

On April 23, 1973, Chemical Marketing Reporter quoted bentonite price increases as follows: Domestic, 200-mesh, bags, carload lots, f.o.b. mines, from $14.00–$14.40 to $15.50–$16.00 per ton; and imported Italian, white, high-gel, bags, 5-ton lots, ex-warehouse, from $116.60 to $337.60 ($0.1688 per pound) per ton. The average unit value reported by domestic producers for bentonite sold or used in 1973 was $11.34, an increase of $0.74 from the $10.60 average of the previous year. Per-ton values reported in the various producing States ranged from $4 to $30, but as in 1972, the average value reported by the larger producers was near the Wyoming average figure of $11.17.

Bentonite imports in 1973, including chemically activated and special-purpose Italian material, totaled 2,670 short tons valued at $243,000, compared with 2,853 tons valued at $229,000 in 1972. The 2,571 tons of chemically activated bentonite was imported from six countries, with Canada supplying 44%; Mexico, 35%; West Germany, 8%; Japan, 12%; and the Netherlands and the United Kingdom the remaining 1%. Imports of Italian bentonite in 1973 decreased from 127 short tons in 1972 to 99 tons.

Table 11.—Bentonite sold or used by producers in the United States, by State

State	1972		1973	
	Short tons	Value	Short tons	Value
Arizona	25,410	$284,660	35,067	$394,588
California	39,787	923,027	49,682	823,102
Colorado	929	6,043	1,012	6,525
Idaho	40	120	W	W
Mississippi	277,596	3,387,514	286,135	3,606,934
Missouri	W	W	74,000	W
Montana	233,390	1,489,361	176,586	1,232,400
Oregon	1,192	14,309	875	10,495
Texas	88,220	1,127,937	84,620	802,182
Utah	4,014	43,803	4,880	64,880
Wyoming	1,811,246	18,359,756	2,106,369	23,529,610
Other States [1]	285,174	3,693,987	253,316	4,368,040
Total	2,766,998	29,330,517	3,072,542	34,838,756

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes Alabama, Nevada, Oklahoma, South Dakota, and data indicated by symbol W.

Bentonite exports in 1973 increased from 521,000 short tons in 1972 valued at $15.1 million to 551,000 tons valued at $18.4 million. Although the tonnage exported increased only 6% from that shipped in 1972, the value increased 22%. The greater increase in value was the result of the unit value of exported bentonite increasing $4.33 per ton, from $29.01 per ton in 1972 to $33.34 per ton. This increase in per-ton value was attributed to a large increase in the amount of higher cost drilling mud and foundry-grade bentonites shipped. Exports in previous years consisted of a larger percentage of the lower cost pelletizing grades. Domestic bentonite producers were facing increased competition in foreign markets. Bentonite from the Greek island of Milos was being blended with the U.S. clay for pelletizing Canadian taconite ores on a large scale.

Bentonite was exported to 77 countries, an increase of 6 from the previous year. The major recipients were Canada, 43%; the United Kingdom and West Germany, 9% each; Australia, 8%; Saudi Arabia, 5%; Japan and the Netherlands, 4% each; and others, 18%. Domestic bentonite producers reported the end use of their exports were foundry sand, 41%; iron ore pelletizing, 29%; drilling mud, 25%; and others, including animal feed, ceramics, ore treatment, and waterproofing and sealing, 5%.

Table 12.—U.S. exports of bentonite as reported by producers, by use

(Short tons)

Use	1972	1973
Drilling mud	56,666	110,430
Foundry sand	167,130	180,383
Pelletizing (iron ore)	183,458	126,998
Other [1]	15,840	20,405
Total	423,094	438,216

[1] Includes animal feed, ceramics, oil treatment, oil refining catalysts, waterproofing and sealing, and other uses.

FULLER'S EARTH

Production of fuller's earth in 1973 increased 15% in quantity and 20% in total value. The unit value assigned by domestic producers increased $0.99 in 1973 to $24.07 per ton. This increase in value was due to modest increases in unit value by both the Florida and Georgia producers.

Fuller's earth production was reported from operations in nine States, an increase of one over 1972. The two top producing States, Georgia (39%) and Florida (37%), accounted for 76% of the domestic production. The other seven States accounted for the remaining 24%. Georgia, Mississippi, Tennessee, California, Florida, Texas, and Utah showed gains in production, while Illinois declined slightly. The new producing State in 1973 was South Carolina.

Fuller's earth is defined as a nonplastic clay or claylike material, usually high in magnesia, which has adequate decolorizing and purifying properties.

In 1973 Southern Clay, Inc., installed new bagging lines and a dryer at its Paris, Tenn., facility. Production from the region that includes Attapulgus (Decatur County), Ga., and Quincy (Gadsden County), Fla., is composed predominantly of the distinct lath-shaped amphibole clay mineral attapulgite. Most of the fuller's earth produced in the other areas of the United States contains varieties of montmorillonite.

Prices for fuller's earth were not publicly quoted in 1973, but the per-ton values re-

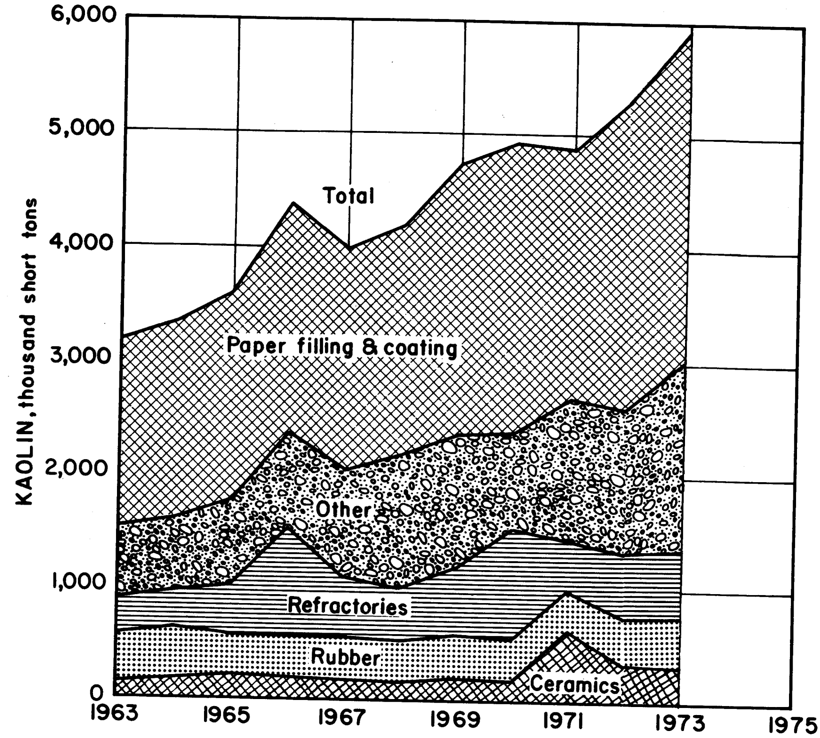

Figure 1.—Kaolin sold or used by domestic producers for specified uses.

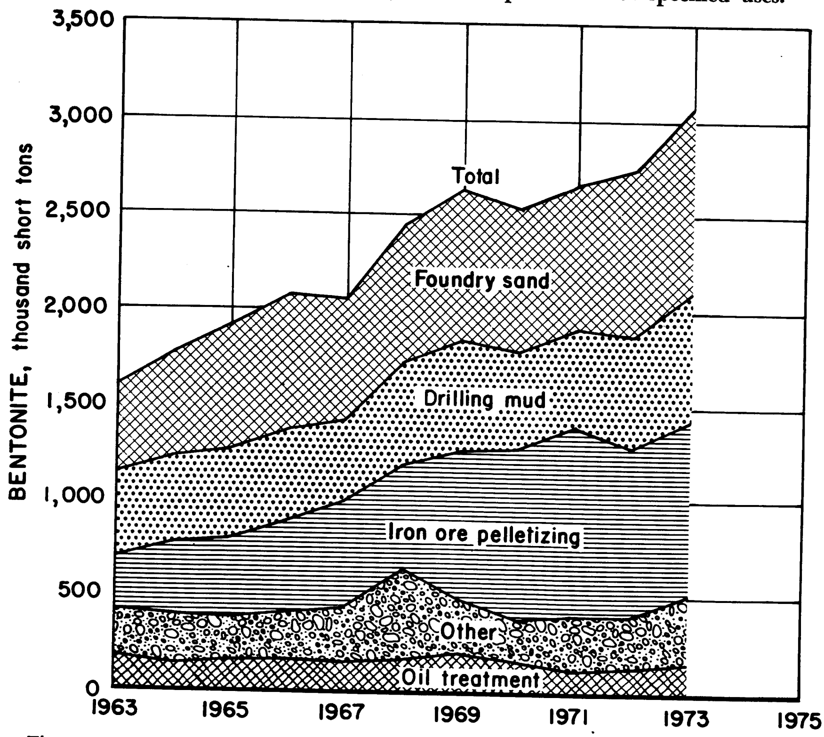

Figure 2.—Bentonite sold or used by domestic producers for specified uses.

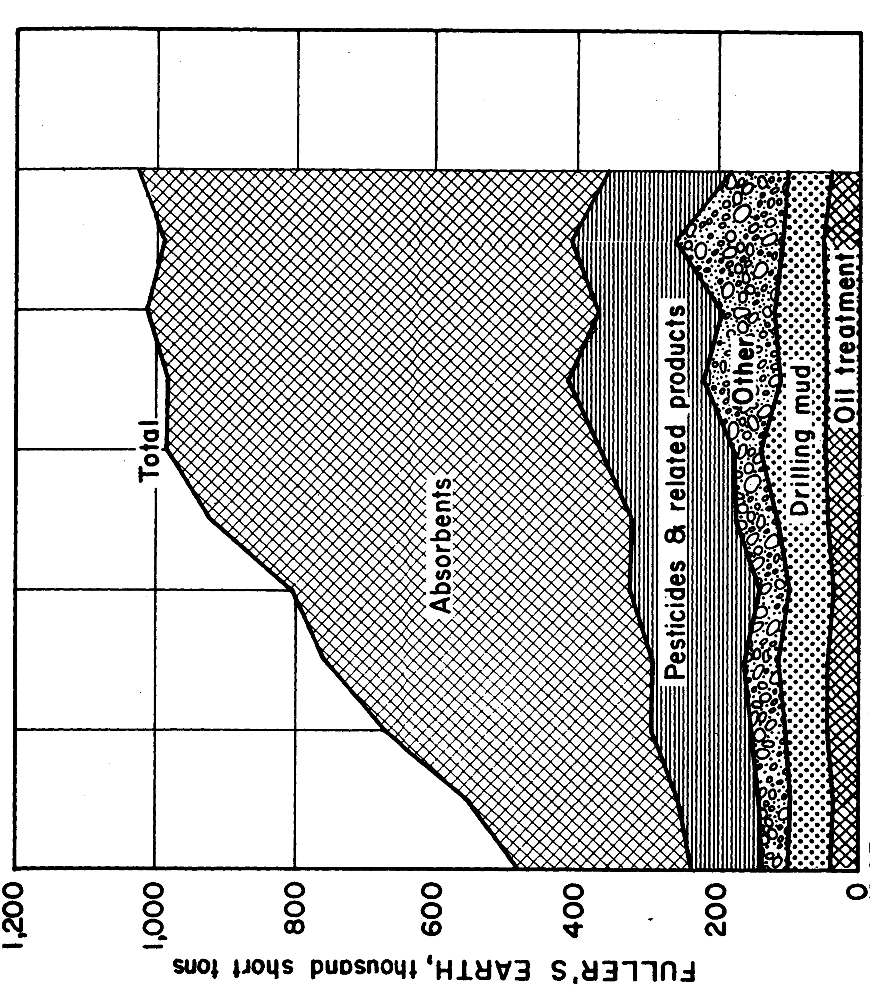

Figure 3.—Fuller's earth sold or used by domestic producers for specified uses.

Table 13.—Fuller's earth sold or used by producers in the United States, by State

State	1972		1973	
	Short tons	Value	Short tons	Value
Florida	353,473	$9,709,923	419,168	$12,001,931
Georgia	405,170	9,053,440	444,326	10,499,157
Utah	2,080	41,857	2,870	62,000
Other States [1]	227,815	4,012,899	272,069	4,835,553
Total	988,538	22,818,119	1,138,433	27,398,641

[1] Includes California, Illinois, Mississippi, South Carolina (1973), Tennessee, and Texas.

ported by producers ranged from $25 to under $40; montmorillonite prices ranged from $10 to under $25.

Exports of fuller's earth to 40 countries increased from 39,000 short tons in 1972 to 58,000 tons valued at $2.7 million in 1973. Export tonnage increased 49%, and its value increased nearly 59%. The unit value of exported fuller's earth rose $2.91 per ton. The major recipients were Canada, 29%; the United Kingdom, 22%; France, 12%; and other countries, the remaining 37%.

Imports of fuller's earth in 1973 were 52 short tons valued at $17,000, all from Japan and West Germany. Imports increased nearly 21%.

COMMON CLAY

Domestic production of common clay and shale in 1973 totaled 49.3 million short tons valued at $79.4 million. Common clay and shale represented 77% of the quantity and 22% of the value of the total clay and shale produced domestically in 1973. In addition, Puerto Rican production of common clay and shale was reported at 463,621 tons valued at $473,195. Domestic output in 1973 increased 7% over that reported for 1972.

Common clays and shales are for the most part used by the producer in fabricating or manufacturing a product. Less than 10% of the total clay and shale output was sold. The average unit value for all common clay and shale produced in the United States in 1973 was $1.61 per short ton, $0.01 more than in 1972. The range in unit value reported for the bulk of the output was from $1 to $2 per ton.

Common clay is defined as a clay or clay-like material which is sufficiently plastic to permit ready mold and vitrification below 1,100° C. Shale is a consolidated sedimentary rock composed chiefly of clay minerals that has been both laminated and indurated while buried under other sediments. These materials are used in the manufacture of structural clay products, such as brick and drain tile, portland cement clinker, and bloated lightweight aggregate.

In 1973 a new brick plant was put on-stream in Endicott, Nebr., by the Endicott Clay Products Co., and another tunnel kiln was added by Continental Clay Products Co. at its Martinsburg, W. Va., facility. Other brick plants were opened by the Henry Brick Co. in Selma, Ala., and in Mississippi. New plants and/or kilns were also put on-stream in Mississippi by Delta Macon Brick and Tile Co., Inc., in Macon and Tri-State Brick and Tile Co., Inc., in Jackson. Oklahoma Brick Corp. announced that its fully automatic 60-million-brick-per-year Oklahoma City plant was fully operational and that it intended to build a $4 million expanded shale aggregate plant at El Reno, Okla. The Onondaga Lightweight Aggregate Corp., Warners, N.Y., completed an expansion project which tripled its capacity. The project included a second sintering hearth and ancillary equipment acquired from the Consolidated Edison Power Co. in New York City. Increased production at Western Brick and Aggregates plant in Nebraska City, Nebr., was accomplished by installing lifters in its rotary kiln.

The output of the energy-intensive common clay and shale industry was curtailed by shortages of fuel, labor, and descumming barium chemicals in 1973. Industrywide attention was focusing on coal firing as a possible escape from the high cost and shortages of oil and gas.

Exports of common clay and shale are not tallied by the U.S. Department of Commerce. Most countries have local deposits of either clays or shales which are adequate for manufacturing structural clay products, cement clinker, and lightweight aggregates, and thus have no need to import such materials.

Table 14.—Common clay and shale sold or used by producers in the United States, by State[1]

State	1972 Short tons	1972 Value	1973 Short tons	1973 Value
Alabama	2,388,062	$3,462,479	2,446,648	$3,537,518
Arizona	108,957	70,441	82,241	64,336
Arkansas	885,147	990,269	1,445,790	1,411,558
California	2,493,297	5,507,604	2,526,158	5,119,251
Colorado	691,718	1,321,013	734,485	1,478,664
Connecticut	156,723	291,864	161,707	320,171
Delaware	15,480	9,288	14,747	8,848
Florida	568,351	625,977	691,570	926,492
Georgia	1,855,555	2,772,308	2,766,378	5,193,999
Idaho	W	W	11,116	18,133
Illinois	1,609,537	2,652,316	1,660,306	3,003,427
Indiana	1,419,141	2,462,468	1,393,483	2,393,666
Iowa	1,047,466	2,642,705	967,396	2,028,001
Kansas	1,169,528	1,456,742	1,169,264	1,489,564
Kentucky	838,573	887,900	940,316	1,040,364
Louisiana	1,000,162	1,454,344	978,523	1,329,396
Maine	40,230	57,031	40,773	74,418
Maryland	1,101,140	2,109,578	896,599	1,973,492
Massachusetts	218,779	415,812	217,053	404,472
Michigan	2,513,808	3,714,690	2,150,706	3,304,398
Minnesota	167,412	251,119	155,555	233,283
Mississippi	1,496,694	1,506,355	1,622,586	2,085,075
Missouri	1,676,958	3,583,323	1,564,697	2,370,701
Montana	70,377	100,610	42,337	65,734
Nebraska	115,033	143,424	158,468	285,761
New Hampshire	50,750	70,125	43,350	63,575
New Jersey	152,514	485,693	156,915	515,200
New Mexico	65,124	107,789	87,808	169,455
New York	1,600,723	1,919,417	1,798,912	2,146,185
North Carolina	3,862,435	4,473,183	4,109,174	5,057,166
Ohio	3,292,878	6,009,840	3,636,309	6,129,983
Oklahoma	937,683	1,397,874	1,297,699	1,871,026
Oregon	149,411	223,111	166,703	280,250
Pennsylvania	1,857,880	5,405,932	2,083,444	5,593,199
Puerto Rico	360,724	382,296	463,621	473,195
South Carolina	1,540,271	2,269,648	1,495,514	2,522,879
South Dakota	185,461	156,140	200,511	181,156
Tennessee	1,286,629	1,273,532	1,231,226	1,338,200
Texas	4,894,299	7,872,486	5,329,859	8,950,981
Utah	256,397	682,741	229,580	612,110
Virginia	1,634,024	1,783,350	1,645,726	1,885,774
Washington	264,093	583,539	286,538	663,873
West Virginia	274,310	402,927	347,833	516,300
Wisconsin	3,851	7,085	1,770	3,186
Wyoming	61,634	149,370	236,148	513,482
Other States[2]	108,374	224,235	87,648	178,018
Total	46,487,593	74,369,973	49,775,190	79,825,915

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes Puerto Rico.
[2] Includes Hawaii, Nevada, North Dakota, and data indicated by symbol W.

CONSUMPTION AND USES

The manufacture of heavy clay products (building brick, sewer pipe, drain tile), portland cement and clinker, and lightweight aggregate accounted for 39%, 20%, and 18%, respectively, of the total 1973 domestic consumption of clays. In summary, 77% of all clay produced in 1973 was consumed in the manufacture of these clay- and shale-based construction materials. The foregoing clay tonnage relationships were similar to those reported for 1972. The utilization of clays in 1973 for heavy clay products and portland cement increased 10% and 2%, respectively, over that reported in 1972.

Heavy Clay Products.—The values reported for shipments of heavy clay products in 1973 rose by 8% to $783 million from the 1972 value of $722 million. The trends in corresponding quantities were less consistent. Thousand-unit counts for building or common face brick increased 6% in 1973 over that shipped in 1972, while shipments of glazed and unglazed ceramic tile and glazed brick, and of clay floor and wall tile decreased 6% and 2%, respectively. The tonnage of unglazed structural tile, and vitrified clay sewer pipe and fittings shipped during the year declined 6% and 5%, respectively. The value of these shipments, except for clay sewer pipe which decreased 5%, rose 14% for building brick, 15% for structural tile, 12% for ceramic tile, and 6% for clay floor and wall tile.

Lightweight Aggregate.—Consumption of clay and shale in the making of lightweight aggregate increased in 1973 to an alltime high of 11,657,978 short tons. This was an 8% increase over the 10.8 million short tons used in 1972.

The tonnage of raw material mentioned in tables 15 and 18 for lightweight aggregate production refers only to clay and shale and does not include the quantity of slate and blast furnace slag similarly used. In 1973, a total 1,092,021 short tons of slate was expanded for lightweight aggregate, 14% below the 1972 figure of 1,269,646 tons. The National Slag Association reported the amount of slag used for lightweight concrete aggregate and in block manufacture increased 23% in 1973, from 1,264,000 tons in 1972 to 1,560,000 tons.

Refractories.—All types of clay were used in manufacturing refractories. Fire clay, bentonite, and kaolin accounted for 72%, 16%, and 10%, respectively, of the total clays used for this purpose. Bentonite was used primarily as a bonding agent in proprietary foundry formulations. Minor tonnages of ball clay (1%), fuller's earth, and common clay and shale (the remaining 1%) were also used, primarily as bonding agents.

The tonnage used for refractories in 1973 increased from 7% in 1972 to 8% of the total clays produced. This slight increase in the use of clay-based refractories continued for a second year, a reversal in the downward pattern set for a number of years. The increase was due primarily to both the continued expansion in refractory aggregate production and an upsurge in the manufacturing of more conventional brick-type refractories. Refractory aggregates are used mostly in plastic, gunning, ramming, and castable mixes.

Filler.—All clays are used to some extent as fillers in one or more areas of use. Kaolin and fuller's earth are the principal filler clays. Kaolin was used in the manufacture of a large number of products, such as paper, rubber, plastics, paint, and fertilizers. The other important filler clay, fuller's earth, was used primarily in pesticides and fertilizers. Clays in pesticides and fertilizers are used either as carriers, diluents, or prilling agents.

Six percent of the clay produced in 1973 was used in filler applications. Kaolin accounted for 90%, and fuller's earth accounted for 6% of all the clay used for these purposes. The other clays accounted for the remaining 4%. The consumption of kaolin decreased, except for paper filling and coating, and pesticide grades which increased 11% and 1%, respectively. Kaolin used in rubber decreased 2%, in fertilizer 5%, in paint 7%, and in plastics 13%. Total quantity of fuller's earth used in insecticides and fungicides increased 21%.

Absorbent Uses.—Absorbent uses for clays, approximately 725,587 short tons, consumed slightly more than 1% of the total 1973 clay production. Demand for absorbents in 1973 increased 22% from that reported for 1972. Fuller's earth was the principal clay used in absorbent applications; 63% of the entire output was consumed for this purpose. Bentonite was used to a lesser degree. Demand for clays in animal litter, representing 47% of the 1973 absorbent demand, decreased 41% from that reported for 1972. Demand for use in floor absorbents, chiefly to absorb hazardous oily substances, represented the remaining 53% of absorbent demand and increased 11% from the 1972 figure.

Drilling Mud.—Demand for clays in rotary-drilling muds increased 7% in 1973, from 596,180 short tons in 1972 to 639,339 tons. This increase in demand, mostly in exploratory gas well drilling and a lesser degree in oil well drilling, was spurred by the deregulation of "new" gas introduced into the interstate market after April 6, 1972. Drilling muds consumed slightly less than 1% of the entire 1973 clay production. Swelling-type bentonite is the principal clay used in drilling mud mixes, although fuller's earth or nonswelling bentonite is also used to a limited extent. Bentonite and fuller's earth accounted for nearly 100% of the total amount of clay used for this purpose. Small amounts of ball clay and common clay and shale were used in specialized formulations.

Floor and Wall Tile.—Common clay and shale, ball clay, fire clay, and kaolin, in order of demand, were used in manufacturing floor, wall, and quarry tile. This tile end-use category accounted for less than 1% of the total clay production in 1973. Demand in 1973, 484,275 short tons, increased 7% from that shown in 1972.

Pelletizing Iron Ore.—Bentonite is used as a binder in forming iron ore pellets. Demand, resuming the general trend which declined last year, increased 10% in 1973 to 776,490 short tons. This rise in the use of bentonite for iron ore pelletizing, reflecting an upturn in steel production, was accomplished in spite of inroads made by cheaper foreign bentonites into a traditional U.S. clay market. Of the total bentonite produced in 1973, about 25% of the swelling variety (a decrease from the 26% in 1972) was consumed for this purpose. U.S. deposits continued to be the major source for swelling bentonites.

Pottery.—The total demand for clays in the manufacture of pottery, sanitary ware, china/dinner ware, and related products, excluding clay flower pots, accounted for 1% of the total 1973 clay output. The total clay demand, principally ball and kaolin clays rose about 7% from 646,515 short tons in 1972 to 691,530 short tons in 1973.

Tabe 15.—Clays sold or used by producers in the United States in 1973, by kind and use, including Puerto Rico

(Short tons)

Use	Ball clay	Bentonite	Common clay and shale	Fire clay (refractory only)	Fuller's earth	Kaolin	Undistributed [1]	Total
Adhesives	(2)	(2)	--	--	(2)	64,653	2,951	67,604
Alum (aluminum sulfate) and other chemicals	--	(2)	--	(2)	(2)	227,780	6,415	234,195
Animal feed	(2)	139,858	125	--	(2)	14,999	646	155,628
Asphalt emulsion and tiles	(2)	(2)	--	--	--	--	15,612	15,612
Brakes and clutches	--	--	929	--	--	--	--	929
Building brick:								
Common	(2)	(2)	3,404,608	--	--	--	732	3,405,340
Face	13,000	2,924	19,063,814	44,473	--	382,619	--	19,506,830
Catalysts (oil refining)	(2)	(2)	--	--	(2)	89,337	10,809	100,146
Caulking, putty, sealers, glue	(2)	--	--	(2)	--	(2)	8,485	8,485
Cement, portland	--	(2)	12,687,751	--	(2)	107,237	23,407	12,818,395
Ceramic—hobby	--	--	543	--	--	--	--	543
China/dinnerware	44,214	--	--	--	--	29,742	--	73,956
Crockery and other earthenware	1,000	--	5,785	(2)	(2)	3,623	22,241	32,649
Drilling mud	(2)	573,328	(2)	--	60,331	--	5,680	639,339
Electrical porcelain	17,135	--	--	--	--	15,910	--	33,045
Fertilizers	--	(2)	(2)	--	39,031	72,278	11,340	122,649
Fiberglass	--	--	--	--	--	189,311	--	189,311
Filtering, clarifying, decolorizing:								
Animal and vegetable oils	--	60,097	--	--	--	--	--	60,097
Mineral oils and greases	--	107,981	--	--	29,981	(3)	--	[4] 137,962
Firebrick, block, shapes	(2)	(2)	(2)	2,445,660	--	312,182	10,991	2,768,833
Flower pots	--	--	62,521	--	--	--	--	62,521
Flue linings	--	--	146,063	89,495	--	(3)	--	[4] 235,558
Foundry sand	--	790,167	--	229,837	--	(3)	--	[4] 1,020,004
Glazes, glass, enamels	1,925	(2)	--	(2)	--	8,137	42,351	52,413
Grogs and crudes, refractory	3,600	--	--	179,766	--	153,179	--	336,545
Gypsum products	--	658	--	--	--	56,255	--	56,913
High-alumina (minimum 50% Al_2O_3) refractories	(2)	--	--	251,448	--	(2)	60,505	311,953
Kiln furniture	(2)	--	--	(2)	--	(2)	22,042	22,042
Lightweight aggregate	--	--	11,657,978	--	--	--	--	11,657,978
Linoleum	--	--	929	--	--	(3)	--	[4] 929
Medical, pharmaceutical, cosmetic	--	3,749	--	--	(2)	(2)	947	4,696
Mortar and cement, refractory	(2)	--	--	519,895	(2)	(2)	33,895	553,790
Oil and grease absorbents	--	26,640	--	--	355,778	--	--	382,418
Oil well sealing	--	--	249	--	--	--	--	249
Paint	--	(2)	--	--	(2)	131,973	5,444	137,417
Paper coating	(2)	(2)	--	--	(2)	1,610,911	3,729	1,614,640
Paper filling	(3)	--	--	--	--	824,625	--	[4] 824,625
Pelletizing (iron ore)	--	776,490	--	--	--	--	--	776,490
Pelletizing (other)	--	--	--	19,200	--	--	--	19,200
Pesticides and related products	(3)	35,711	--	--	175,332	28,750	--	[4] 239,793

Pet absorbent	--	10,680	--	--	332,489	--	--	343,169
Plastics	--	--	(2)	--	(2)	62,628	478	63,106
Plug, tap, wad	--	--	--	6,560	--	--	--	6,560
Pottery	170,786	--	17,496	13,015	--	15,150	--	216,447
Roofing granules	--	--	--	--	(3)	306	--	[4] 306
Rubber	465	--	--	--	--	366,698	--	367,163
Sanitary ware	187,362	--	--	--	--	181,116	--	368,478
Sewer pipe, vitrified	--	--	1,817,268	100,940	--	--	--	1,918,208
Tile:								
Drain	--	--	341,686	--	--	--	--	341,686
Floor and wall, ceramic	123,420	--	132,017	50,054	--	33,995	--	339,486
Quarry	1,000	--	143,789	--	--	--	--	144,789
Roofing	--	--	80,653	--	--	--	--	80,653
Structural	--	--	104,982	--	--	--	--	104,982
Terra cotta	--	--	(2)	(2)	--	--	23,645	23,645
Other	--	--	--	--	--	5	--	5
Waterproofing and sealing	--	57,523	--	--	(3)	--	--	[4] 57,523
Miscellaneous [5]	18,950	21,951	14,039	7,412	5,417	82,462	--	150,231
Undistributed	99,471	26,569	35,624	67,515	29,532	53,634	--	--
Exports	84,384	438,216	56,341	42,713	110,542	873,984	--	1,606,180
Total	766,712	3,072,542	49,775,190	4,067,983	1,138,433	5,993,479	(6)	64,814,339

[1] Total of clays indicated by footnote 2.
[2] Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[3] Withheld to avoid disclosing individual company confidential data; included with "Miscellaneous."
[4] Incomplete figure; remainder included with "Miscellaneous."
[5] Includes abrasives, graphite anodes, tamping dummies, ink, mineral wool and insulation, textiles, water treatment and filtering, unknown uses, and data indicated by footnote 3.
[6] "Undistributed" total included with total for each specific use.

Table 16.—Shipments of principal structural clay products in the United States

Products	1969	1970	1971	1972	1973
Unglazed building or common and face brick:					
Quantity ------thousand standard brick--	7,289,669	6,495,995	7,569,726	8,402,217	8,922,672
Value ------thousands--	$318,892	$287,131	$346,390	$403,774	$460,099
Unglazed structural tile:					
Quantity ------short tons--	241,509	181,046	152,536	100,534	94,239
Value ------thousands--	$6,875	$5,903	$4,432	$3,084	$3,555
Vitrified clay sewer pipe and fittings:					
Quantity ------short tons--	1,783,546	1,622,339	1,720,597	1,717,991	1,637,546
Value ------thousands--	$120,420	$119,048	$133,067	$143,082	$136,517
Unglazed, salt glazed, and ceramic glazed structural facing tile, including glazed brick:					
Quantity ------thousand brick--	203,039	168,985	153,486	130,760	122,951
Value ------thousands--	$19,917	$16,130	$15,033	$13,191	$14,761
Clay floor and wall tile and accessories, including quarry tile:					
Quantity ------thousand brick--	203,039	168,985	153,486	130,760	122,951
Value ------thousands--	$142,878	$126,219	$142,645	$159,105	$168,255
Total value ------thousands--	$608,982	$554,431	$641,567	$722,236	$783,187

Table 17.—Clay and shale used in building brick production in the United States in 1973, by State

State	Short tons	Value	State	Short tons	Value
Alabama	1,126,716	$1,775,051	Nebraska	70,841	$152,041
Arizona	82,241	64,436	New Hampshire	43,350	63,555
Arkansas	476,166	467,344	New Jersey	117,441	396,703
California	368,021	801,401	New Mexico and North Dakota	71,477	59,692
Colorado	425,690	967,545	New York	313,341	555,048
Connecticut	152,157	302,495	North Carolina	3,119,959	3,704,026
Delaware	14,747	8,848	Ohio	1,689,036	2,995,476
Florida	31,490	34,639	Oklahoma	578,393	806,157
Georgia	2,473,259	4,686,181	Oregon	41,245	66,933
Hawaii and Michigan	82,744	130,917	Pennsylvania	1,616,130	4,787,672
Idaho	11,116	18,134	South Carolina	1,276,400	2,170,648
Illinois	564,447	1,283,362	South Dakota	16,580	16,580
Indiana	635,900	1,059,500	Tennessee	667,807	820,935
Iowa	276,835	438,552	Texas	1,557,710	3,450,152
Kansas	408,658	497,878	Utah and West Virginia	272,125	531,379
Kentucky	331,185	341,022	Virginia	1,099,022	1,289,467
Louisiana	224,021	319,714	Washington	152,442	307,487
Maine	40,740	74,311	Wisconsin	1,770	3,186
Maryland and Massachusetts	533,772	1,417,406	Wyoming	62,949	227,925
Minnesota and Montana	51,105	75,811			
Mississippi	1,160,191	1,520,263			
Missouri	229,203	568,995	Total	22,468,422	39,258,867

Table 18.—Clay and shale used in lightweight aggregate production in the United States in 1973, by State, including Puerto Rico

State	Short tons	Value
Alabama and Arkansas	1,588,305	$1,521,559
California	891,896	1,944,799
Colorado, Florida, Indiana	741,208	1,046,567
Illinois and Iowa	979,770	1,603,438
Kansas, Kentucky, Louisiana	743,900	906,625
Maryland, Massachusetts, Michigan	654,842	1,038,728
Minnesota and Missouri	248,810	459,616
Mississippi	428,923	433,212
Montana	25,509	42,472
Nebraska, North Carolina, Ohio	1,027,344	1,231,599
New York	1,010,994	1,085,799
North Dakota, Oklahoma, Oregon	340,539	553,321
Pennsylvania, South Dakota, Utah	267,261	448,981
Tennessee	328,000	326,400
Texas	2,042,423	2,745,398
Virginia, Washington, Puerto Rico	338,254	367,369
Total	11,657,978	15,755,883

Table 19.—Shipments of refractories in the United States, by kind

Product	Unit of quantity	Shipments 1972 Quantity	Shipments 1972 Value (thousands)	Shipments 1973 Quantity	Shipments 1973 Value (thousands)
CLAY REFRACTORIES					
Fire clay (including semisilica) brick and shapes, except superduty; glasshouse pots, tank blocks, feeder parts, and upper structure shapes used only for glass tanks.[1]	1,000 9-inch equivalent	214,475	r $49,475	234,781	$55,551
Superduty fire clay brick and shapes	----do------	67,826	24,930	68,147	26,715
High-alumina brick and shapes (50% Al_2O_3 and over) made substantially of calcined diaspore or bauxite.[1 2]	----do------	r 74,735	51,524	86,491	64,254
Insulating firebrick and shapes	----do------	44,684	14,824	54,373	18,332
Ladle brick	----do------	r 194,341	r 30,499	214,784	35,511
Sleeves, nozzles, runner brick, tuyeres	----do------	47,265	15,979	50,647	18,289
Hot-top refractories	Short tons	r 25,504	r 1,985	21,677	1,731
Clay-kiln furniture, radiant-heater elements, potters' supplies, other miscellaneous shaped refractory items.	------------	NA	11,883	NA	13,599
Refractory bonding mortars, air-setting (wet and dry types).[3]	Short tons	67,019	11,263	101,318	16,378
Refractory bonding mortars, except air-setting types.[3]	----do------	8,632	1,262	11,024	1,691
Plastic refractories and ramming mixes[4]	----do------	174,403	18,162	207,497	22,091
Castable refractories (hydraulic-setting)	----do------	192,624	24,528	212,682	28,286
Insulating castable refractories (hydraulic-setting)	----do------	44,642	7,647	45,725	8,012
Other clay refractory materials sold in lump or ground form.[5 6]	----do------	368,660	10,046	454,560	13,039
Total clay refractories		XX	r 274,007	XX	323,479
NONCLAY REFRACTORIES					
Silica brick and shapes	1,000 9-inch equivalent	32,437	12,877	36,668	15,309
Magnesite and magnesite-chrome brick and shapes, magnesite predominating (excluding molten-cast and fused magnesia).	----do------	r 87,763	r 107,620	110,487	146,311
Chrome and chrome-magnesite brick and shapes, chrome predominating (excluding molten-cast).	----do------	18,713	20,044	19,964	24,420
Graphites crucibles, retorts, stopper heads, and other shaped refractories containing natural graphite.	Short tons	15,756	15,759	18,567	18,313
Mullite brick and shapes made predominantly of kyanite, sillimanite, andalusite, or synthetic mullite, excluding molten-cast.	1,000 9-inch equivalent	4,517	8,917	4,918	9,961
Extra-high-alumina brick and shapes made predominantly of fused bauxite or fused or dense-sintered alumina, excluding molten-cast.[7]	----do------	r 2,475	8,629	2,998	11,379
Silicon carbide brick and shapes made predominantly of silicon carbide, including kiln furniture.	----do------	3,355	13,347	4,635	19,759

See footnotes at end of table.

Table 19.—Shipments of refractories in the United States, by kind—Continued

Product	Unit of quantity	Shipments 1972 Quantity	1972 Value (thousands)	1973 Quantity	1973 Value (thousands)
NONCLAY REFRACTORIES—Continued					
Zircon and zirconia brick and shapes made predominantly of either of these materials.	1,000 9-inch equivalent	1,785	$6,571	2,387	$8,785
Forsterite, pyrophyllite, dolomite, dolomite-magnesite, molten-cast and other nonclay brick and shapes including carbon refractories, except those containing natural graphite.[8]	----do------	r 33,882	r 64,019	37,187	73,258
Mortars:					
Basic bonding mortars, magnesite or chrome ore predominating.	Short tons--	11,465	1,355	16,198	1,639
Other nonclay refractory mortars	----do------	r 29,855	5,995	32,217	7,057
Nonclay refractory castables, hydraulic-setting	----do------	r 49,282	r 12,813	62,300	15,752
Plastic refractories and ramming mixes, wet and dry types:					
Basic—magnesite, dolomite, or chrome ore predominating.	----do------	r 129,225	18,371	141,339	22,062
Other nonclay plastic refractories and ramming mixes.	----do------	80,884	19,394	99,431	24,174
Dead-burned magnesia or magnesite	----do------	115,164	10,075	123,373	11,237
Nonclay gunning mixes	----do------	303,108	35,817	352,887	41,880
Other nonclay refractory materials sold in lump or ground form.[5]	----do------	342,587	11,620	393,280	13,745
Total nonclay refractories		XX	r 373,223	XX	465,041
Grand total refractories		XX	r 647,230	XX	788,520

r Revised. NA Not available. XX Not applicable.

1 Excludes data for mullite and extra-high-alumina refractories; these products are included in the nonclay refractories section.

2 Calcined as applied to diaspore and bauxite implies heat treatment short of fusion for volume stability prior to use in a refractory product. In the process volatile materials are driven off and chemical changes take place.

3 Includes bonding mortars which contain up to 60% Al_2O_3 dry basis; bonding mortars which contain more than 60% Al_2O_3 are included in the nonclay refractories section.

4 Includes products referred to as plastic fire brick and the less plastic materials intended for ramming into place after the addition of water, when shipped in dry form; excludes mixes made of mullite or alumina, which are included in the nonclay refractories section.

5 Includes shipments for direct use as finished refractory products by establishments classified in "manufacturing" industries and excludes shipments to refractory producers for reprocessing in the manufacture of brick and other refractories.

6 Includes data for calcined clay, ground brick and siliceous and other gunning mixes.

7 Fused as applied to bauxite and alumina means complete melting, as in an electric furnace; after cooling, the product is crushed and graded for use in the refractory. Dense-sintered alumina refers to heat treatment (short of melting) to render it relatively volume-stable for use in a refractory.

8 Molten-cast refractories are made by fusing refractory oxides, as in an electric furnace, and pouring the molten material into molds to form finished shapes.

Table 20.—U.S. exports of clays by country and class in 1973

(Thousand short tons and thousand dollars)

Country	Bentonite		Fire clay		Fuller's earth		Kaolin		Ball clay		Clays, n.e.c.		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Australia	46	1,234	1	33	1	16	13	389	--	--	16	736	77	2,408
Brazil	15	558	1	21	1	14	2	128	1	33	12	1,021	32	1,775
Canada	238	5,068	110	1,032	17	800	159	5,093	54	988	111	3,089	689	16,070
Chile	1	22	1	131	--	--	(1)	38	(1)	1	(1)	12	2	204
Colombia	2	127	(1)	4	(1)	1	(1)	18	--	--	4	192	6	342
France	6	478	2	142	7	465	6	284	--	--	22	1,528	43	2,897
Germany, West	47	1,301	6	190	3	87	145	5,548	--	--	13	572	214	7,698
Indonesia	1	41	--	--	(1)	13	--	--	--	--	1	56	2	110
Italy	1	141	3	220	2	81	80	3,541	--	--	44	2,635	130	6,618
Japan	23	1,463	9	458	(1)	13	229	11,188	3	113	107	5,798	371	19,033
Mexico	1	80	51	1,087	(1)	2	33	1,316	51	824	10	232	146	3,541
Netherlands	24	568	1	38	4	316	2	98	--	--	15	844	46	1,864
Philippines	2	200	1	29	(1)	7	1	41	3	105	11	538	18	920
Saudi Arabia	25	1,409	(1)	1	--	--	--	--	(1)	14	(1)	10	25	1,434
Singapore	16	881	(1)	1	1	24	(1)	11	(1)	5	(1)	27	17	949
South Africa, Republic of	3	320	(1)	7	(1)	16	2	164	(1)	3	4	241	9	751
Sweden	1	60	(1)	4	(1)	20	10	344	(1)	4	2	119	13	551
Taiwan	2	106	(1)	16	--	--	(1)	23	--	--	18	900	20	1,045
United Kingdom	50	1,569	7	131	13	363	24	603	(1)	6	4	337	98	3,009
Venezuela	17	597	1	21	1	33	12	640	1	32	3	170	35	1,493
Other	30	2,145	2	254	8	468	14	1,061	1	69	49	3,065	104	7,062
Total	551	18,368	196	3,820	58	2,739	732	30,528	114	2,197	446	22,122	2,097	79,774

[1] Less than ½ unit.

Table 21.—U.S. imports for consumption of clay in 1973

Kind	Quantity (Short tons)	Value (thousands)
China clay or kaolin, whether or not beneficiated:		
Canada	587	$29
Germany, West	(1)	(1)
Japan	121	26
United Kingdom	33,495	826
Total	34,203	881
Fuller's earth, not beneficiated: Germany, West	2	3
Fuller's earth, wholly or partly beneficiated: Japan	50	14
Bentonite: Italy	99	7
Common blue and other ball clay, not beneficiated: United Kingdom	9,173	168
Common blue or other ball clay, wholly or partly beneficiated:		
Canada	11	3
United Kingdom	3,337	116
Total	3,348	119
Clays, n.e.c., not beneficiated: Germany, West	95	15
Clays, n.e.c., wholly or partly beneficiated:		
Canada	72	7
Germany, West	105	15
Japan	776	196
Mexico	608	106
United Kingdom	1,540	112
Total	3,101	436
Clays artificially activated with acid:		
Canada	1,133	56
Germany, West	203	24
Japan	331	83
Mexico	904	72
Netherlands	(1)	(1)
United Kingdom	(1)	1
Total	2,571	236
Grand total	52,642	1,879

[1] Less than ½ unit.

WORLD REVIEW

Australia.—English China Clay Ltd. (ECC) and Abaleen Minerals NL disclosed additional information regarding their kaolin plans. ECC's new plant near Melbourne went on-stream, producing kaolin intended primarily for the Asian market. The new plant was to enable ECC to compete more effectively in Asia. Abaleen announced it was now able to acquire kaolin lease titles near Port Lincoln in South Australia. Previously Abaleen was working in agreement with three other companies. Abaleen's reserves were put at over 22 million tons with production scheduled for 1974. Production was targeted mostly for Europe and Asia. Preliminary tests on bulk samples from Abaleen's prospects showed the minus 2-micron kaolin fraction was highly suitable for papermaking. Presently, there is no Australian production of high-quality coating clays.[3]

The Yenyenning kaolin deposits in Western Australia were reported to contain two unspecified grades of economically important kaolins. Provisional estimates were around 7 million tons of high-grade material.[4]

Austria.—Kernfest-Ashland-Süd-Chemie Gieserei Chemikalien GmbH, formed by Ashland Chemical Co. and Süd-Chemie, acquired a 50% interest in Georg Hantos and Co. of Vienna. Hantos is an established supplier to the Austrian foundry market. The newly formed, jointly owned company was believed to be handling Wyoming bentonite. Ashland, through its association with Federal Bentonite Co. (USA), sells Federal's foundry line.[5]

Belgium.—A new rotary kiln 246 feet long and 15 feet in diameter was put onstream by Argex S.A. in Antwerp to supplement the output of its older kilns. Argex produces over 10% of the world's Leca expanded clay aggregates at its plant on the mouth of the Scheldt River. A significant

[3] Industrial Minerals. No. 65, February 1973, p. 29.

[4] Industrial Minerals. No. 66, March 1973, p. 32.

[5] Industrial Minerals. No. 72, September 1973, p. 73.

Table 22.—Kaolin: World production, by country

(Thousand short tons)

Country [1]	1971	1972	1973 p
North America:			
Mexico	80	79	104
United States [2]	4,886	5,318	5,993
South America:			
Argentina	r 75	98	e 100
Chile	r 63	60	49
Colombia	106	111	e 111
Ecuador	1	e 1	e 1
Paraguay	1	4	9
Peru	(3)	r e (3)	e (3)
Europe:			
Austria (marketable)	102	99	e 90
Belgium e	110	110	110
Bulgaria	152	e 165	e 165
Czechoslovakia	445	e 468	e 468
Denmark e	20	20	20
France [4]	598	e 580	e 580
Germany, West (marketable)	460	460	460
Greece	r 60	e 61	e 61
Hungary e	80	80	80
Italy:			
Crude	106	76	80
Kaolinitic earth	16	17	e 18
Portugal	50	49	49
Romania e	55	55	55
Spain (marketable) [5]	357	386	e 390
U.S.S.R. e	2,100	2,200	2,300
United Kingdom	r 3,064	3,366	e 3,200
Africa:			
Angola	1	1	1
Egypt, Arab Republic of	49	27	28
Ethiopia (including Eritrea)	11	29	e 30
Kenya	--	1	1
Malagasy Republic	2	2	2
Mozambique	2	2	(3)
Nigeria	(3)	--	NA
South Africa, Republic of	43	42	43
Swaziland	2	2	2
Tanzania	1	2	1
Asia:			
Bangladesh	e 2	e 2	7
Hong Kong	3	3	7
India:			
Salable	203	317	282
Processed	r 117	129	235
Indonesia (kaolin powder)	11	7	32
Iran [6]	53	61	e 61
Israel	22	32	e 32
Japan	420	356	430
Korea, Republic of	211	203	416
Malaysia	13	116	116
Pakistan	3	5	1
Sri Lanka	3	4	15
Taiwan [7]	r e 11	18	23
Thailand	11	17	21
Vietnam, South e	1	1	1
Oceania:			
Australia [8]	84	e 100	e 100
New Zealand	22	10	10
Total	r 14,288	15,352	16,390

e Estimate. p Preliminary. r Revised. NA Not available.

[1] In addition to the countries listed, Brazil, People's Republic of China, East Germany, Lebanon, Southern Rhodesia, and Yugoslavia also produced kaolin, but information is inadequate to make reliable estimates of output levels. Morocco produced less than 500 tons in each of the years covered by this table.

[2] Kaolin sold or used by producers.

[3] Less than ½ unit.

[4] Includes kaolinitic clay.

[5] Excludes unwashed kaolin as follows in short tons: 1971—118,256; 1972—115,743; 1973—116,000 (estimated). This material has a value of less than 1/10th of the washed kaolin reported in table.

[6] Year beginning March 21 of that stated.

[7] Data given are for ceramic and pottery and paper filler clays.

[8] Includes ball clay.

portion of the plant's output, now rated at 1 million cubic yards per year, was exported, largely to Britain but also to other European countries.[6]

Brazil.—Ashland Chemical Co., in another overseas marketing expansion, set up a new company, Ashland Resinas Synteticas S.A. in São Paulo, with Bentonit União to sell both Ashland's present foundry chemicals and unannounced newer products.[7] A large kaolin deposit of good quality was located on the Jari River, a tributary of the Amazon, by National Bulk Carriers, Inc. Feasibility tests were underway to determine if processing facilities were warranted.[8]

Canada.—Indusmin Ltd. abandoned a kaolin prospect in northern Ontario and a bentonite project in Saskatchewan.[9] Production of iron-pelletizing-grade bentonite was started by Inland Cement Industries, Ltd., at its Regina, Saskatchewan, plant. Acceptance of this bentonite as a substitute for Wyoming material by the eastern Canadian iron ore operations was expected to result in construction of a separate Saskatchewan facility. Inland Cement's deposits are about 50 miles south of Regina near Truax.[10]

Czechoslovakia.—Additional capacity was added by the major kaolin-processing companies to meet increasing demand for their paper-filling grades. In spite of intensive research, these companies have been unsuccessful in producing acceptable paper-coating clays.[11]

France.—The diversified Saint-Gobain-Pont-A-Mousson group gained control of a major French refractory manufacturer, Société Genérale des Produits Réfractaires S.A. (SGPR), by purchasing Pechiney Ugine Kuhlmann's 33% interest.[12] The St. Gobain

[6] Ironman, R. International Reports. Rock Products v. 76, No. 6, June 1973, p. 136.
[7] Industrial Minerals. No. 72, September 1973, p. 37.
[8] Murray, H. H. Kaolin. Min. Eng., v. 26, No. 2, February 1974, p. 112.
[9] Industrial Minerals. No. 71, August 1973, p. 54.
[10] Skillings' Mining Review. V. 62, No. 35, Sept. 1, 1973, p. 18.
[11] Work cited in footnote 8.
[12] Industrial Minerals. No. 64, January 1973, p. 28.

Table 23.—Bentonite: World production, by country
(Short tons)

Country [1]	1971	1972	1973 [p]
North America:			
Mexico	63,524	41,870	50,478
United States	[r] 2,665,759	2,766,998	3,072,542
South America:			
Argentina	94,764	96,571	[e] 99,000
Colombia	[e] 1,100	[e] 1,100	1,323
Peru	32,494	[e] 40,000	[e] 40,000
Europe:			
France	19,092	[e] 22,000	[e] 22,000
Greece	[r] 234,505	413,822	[e] 441,000
Hungary	78,264	87,082	[e] 94,000
Italy	327,102	303,490	329,974
Poland [e]	55,000	55,000	55,000
Romania [e]	132,000	132,000	132,000
Spain	42,167	47,526	[e] 50,000
Africa:			
Algeria (bentonitic clay)	10,490	21,947	[e] 22,000
Morocco	[r] 4,190	9,590	9,511
Mozambique	6,009	2,637	2,660
South Africa, Republic of	22,745	26,799	27,646
Asia:			
Burma	[r] [2] 383	1,439	927
Cyprus (bentonitic clay) [3]	13,849	12,038	9,792
Iran	14,330	[e] 15,000	[e] 15,000
Israel (metabentonite)	2,756	2,205	[e] 2,200
Pakistan	[r] 119	530	449
Philippines	[r] 147	67	[e] 77
Turkey	[e] 2,200	[r] [e] 5,500	8,613
Oceania:			
Australia [4]	[r] 317	[r] [e] 390	[e] 390
New Zealand	12,964	683	1,136
Total	[r] 3,836,270	4,106,284	4,487,718

[e] Estimate. [p] Preliminary. [r] Revised.
[1] In addition to the countries listed, Austria, Canada, the People's Republic of China, West Germany, Japan, and the U.S.S.R. are believed to have produced bentonite, but output is not reported and available information is inadequate to make reliable estimates of output levels.
[2] Data are for year ending June 30 of that stated.
[3] Exports.
[4] Including bentonitic clay.

Table 24.—Fuller's earth: Noncommunist world production, by country

(Short tons)

Country [1]	1971	1972	1973 [p]
Algeria [e]	66,000	66,000	66,000
Argentina	1,033	528	[e] 600
Australia [2]	[r] 100	[e] 100	[e] 100
Italy	82,626	82,662	[e] 83,000
Mexico	22,316	33,501	55,449
Morocco (smectite)	15,711	17,017	21,078
Pakistan	[r] 11,836	12,397	12,494
Senegal (attapulgite)	3,097	3,405	[e] 3,400
South Africa, Republic of	1,347	2,091	1,010
United Kingdom [e]	193,000	193,000	193,000
United States	1,013,914	988,538	1,138,433
Total	[r] 1,410,980	1,399,239	1,574,564

[e] Estimate. [p] Preliminary. [r] Revised.
[1] In addition to the countries listed, France, Iran, Japan, and Turkey have reportedly produced fuller's earth in the past and may continue to do so, but output is not reported and available information is inadequate to make reliable estimates of output levels. Similarly, no information is available on output in the Communist nations of Europe and Asia, but at least some of them also are presumably producing fuller's earth.
[2] Data are for year ending June 30 of that stated.

group also concentrated its refractory activities under a new company, Société Europiene des Produits Réfractaires S.A. (SEPR). SGPR, a vertically integrated company, produces a range of clay and non-clay refractories as well as insulating firebricks and fused-cast refractories.[13]

Modifications of the Engelhard Minerals & Chemicals Corp. and Solvay's jointly owned Brittany kaolin facility were completed, and limited quantities of filler and coating-grade clays were shipped to European markets.[14]

Greece.—Total reserves of irregular kaolin deposits on the islands of Milos and Lesbos, and smaller occurrences on Santorni and Paliaigos, were put at 2.5 million tons proven and 3.5 million tons probable material. The kaolin occurs in grades suitable for paper coating and filler, and for manufacturing cement, refractories, and ceramics. The total bentonite reserves on Milos were 11 million tons proven and 17 million tons probable and possible. The two largest Milos bentonite producers, Silver and Baryte Ores Mining Co. and Mykobar S.A., were undergoing plant enlargements.[15]

Guyana.—The Government has intensified efforts to delineate kaolin reserves in light of Japanese, East German, and American interests. Proven reserves at Topirah (site of a large bauxite mine), in the upper Demerara region, have been estimated at 2.2 million tons where the bauxite has already been mined. Additional reserves totaling 6 to 7 million tons were reported to be adjacent to existing mining areas. Georgia-quality kaolins are believed to accompany the bauxite. Plans were also formulated to set up a kaolin-processing plant at Topirah with Japanese participation. The East Germans were concerned with manufacturing porcelain. The interested U.S. company, Philipp Bros., is the marketing agent for the state-owned Guyana Bauxite Co. and is also a member of the Englehard group which mines and processes Georgia kaolin.[16]

India.—Plans were announced by Minechem Processors and Grinders (associated with Dhandhania and Co.) to produce 25,000 tpy of china clay, quartz, feldspar, limestone, and soapstone through its grinding and calcining facilities in Bihar beginning in 1974.[17]

Indonesia.—An unnamed U.S. company was participating with the P. N. Timah Co. in exploring a large kaolin deposit.[18]

Italy.—S. A. Mineraria Isole Pontine (SAMIP), already mining an extensive high-grade bentonite deposit on the island of Ponza, announced discovery of a 3-million-ton deposit in Sardinia. The deposit is located near Isili and Nurallao. Preliminary reports imply the deposit may contain as much as 10 million tons of bentonite. Süd-Chemie, the Bavarian bentonite producer,

[13] Industrial Minerals. No. 69, June 1973, pp. 33–34.
[14] Work cited in footnote 8.
[15] Industrial Minerals. No. 75, December 1973, p. 40.
[16] Industrial Minerals. No. 72, September 1973, pp. 31–32.
Mining Magazine. V. 128, No. 3, March 1973, p. 201.
[17] Work cited in footnote 9.
[18] Work cited in footnote 8.

reported it was constructing a plant at Giba in southwest Sardinia. SAMIP and Süd-Chemie now join two other companies, Baroid S.p.A., a subsidiary of NL Industries, Inc., and Industria, Chemia Carlo Laviosa, already working the Sardinian bentonites.[19]

Japan.—International Trading Co., Inc., exporting agent for Georgia Kaolin Co., and Sumitomo Metal Mining Co. Ltd. constructed a new bulk terminal near Osaka.[20] This bulk terminal should lower delivery costs to Japanese markets. Bulk shipments to Europe started in the mid-1960's.

Netherlands.—A 50% interest in the second largest Dutch refractory producer. Chamotte-Unie NV of Geldermalsen, was reportedly taken by Gibbons Dudley Ltd. of the United Kingdom.[21] Rotterdam is currently being used by Euroclay Handelmaatschapij NV, a joint undertaking of Georgia Kaolin Co. (GK) and Amberger Kaolinwerke AG (West Germany), for a storage and distribution center for supplying GK's filling and coating clays to the European paper industry. Euroclay can store up to 30,000 tons to insure delivery.[22]

New Zealand.—New Zealand processed bentonites, available in 5,000- to 5,500-ton lots either bulk or bagged, were offered for sale in Australia by Bulk Minerals Pty. Ltd.[23]

Spain.—Laporte Industries of the United Kingdom bought a 40% interest in the Spanish bentonite producer, Minas de Gador. This privately owned company accounts for 80% of the Spanish bentonite production. Laporte, the largest bentonite producer in the United Kingdom, has facilities at Redhill in Surrey and Combe Hay in Bath, Somerset. Laporte is expected to develop the company's deposits and furnish technology for constructing acid-activating and sodium-base exchanging facilities near Almeria.[24] Argilexpand of Vallés, in Barcelona Province, planned to erect a sodium bentonite processing plant on an undisclosed site.[25]

Turkey.—A new vertically integrated company, Sogut Seramik Sanayii AS, was formed to establish a ceramics industry in the Sögüt area of Bilecik in Western Anatolia.[26]

United Kingdom.—Applied Aluminum Research Corp. of the U.S.A. in conjunction with the London merchant bankers, Bremar Holdings, revealed details of the world's first semicommercial plant to produce aluminum metal by the Toth process. This semicommercial plant, probably located within the United Kingdom, reportedly will cost about $25 million to build and have a metal capacity of 35,000 tons per year.[27] ECC continued modernizing its old installation in Cornwall. The planning permission for extending ECC's operation into Lee Moor was received following assurances about various environmental safeguards.[28]

Production of Laponite, a synthetic hectorite-type clay, was to be expanded at Laporte Industries' Stallingborough plant near Grimsby. Hectorite is mined in the United States. Laponite and hectorites have the unique ability to produce clear suspensions and gels at extremely low concentrations, and are finding increasing application as thickeners in highly specialized fields and for their heat-resistant, anti-static, nontoxic, and clarifying properties.[29]

The Refractories Division of the Gibbons Dudley Ltd. group, consisting of Gibbons Refractories Ltd., United Fireclay Products Ltd., and Thomas Wragg and Sons (Sheffield) Ltd., has formed a new company, Gibbons International Refractories Ltd., to coordinate exports for the entire division.[30]

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[19] Industrial Minerals. No. 71, August 1973, p. 37.
[20] Work cited in footnote 8.
[21] Work cited in footnote 9.
[22] Industrial Materials. No. 65, February 1973, pp. 40–43.
[23] Industrial Minerals. No. 69, June 1973, p. 53.
[24] Work cited in footnote 19.
[25] Industrial Minerals. No. 68, May 1973, p. 4.
[26] Industrial Minerals. No. 68, May 1973, p. 39.
[27] Industrial Minerals. No. 71, August 1973, pp. 38–39.
[28] Industrial Minerals. No. 65, February 1973, p. 32.
[29] Industrial Minerals. No. 74, November 1973, p. 31.
[30] Industrial Minerals. No. 68, May 1973, p. 29.

TECHNOLOGY

The Bureau of Mines at its Boulder City (Nev.) Metallurgy Laboratory initiated plans to set up and operate miniplants utilizing the more promising processes for extracting alumina from nonbauxitic materials, starting with the nitric acid processing of Georgia kaolin. The nitric and hydrochloric acid processes, the next to be studied, for treating alumina-bearing clays were judged the most promising for economically producing alumina from nonbauxitic ores. Other aluminiferous materials scheduled for future miniplant studies include other clays, anorthosite, dawsonite, and alumina-bearing wastes, such as shales and slates, from coal mining and processing. A cooperative project between the Bureau of Mines and the aluminum industry was being explored.

Work at Applied Aluminum Research Corp. (AARC)[31] and Reynolds Metal Co.[32] on direct aluminum metal processes was described. AARC's process, called the Toth process, applicable to clays and bauxites, begins by chlorinating a calcined clay in the presence of a reductant, such as coke, followed by fractional condensation to separate the aluminum, iron, silicon, and titanium chlorides. The separated aluminum chloride is subsequently reduced to aluminum metal and manganese chloride. The manganese chloride is further processed to both recover and recycle the manganese metal and chlorine. The other fractionally condensed metal chlorides are either converted to oxides, thereby recovering the chlorine, or sold as is.

The Reynolds process involves reducing titaniferous clays in a fused-salt bath to an aluminum-titanium alloy. The alloy is kept molten below 1,000° C causing it to separate into a low-titanium and aluminum supernatant and a heavier high-titanium and aluminum intermetallic compound. The intermetallic compound is periodically tapped, leaving a recoverable supernatant phase.

Other patents issued during the year cover a prereduction process for producing alumina and aluminum alloys from clays[33] and a method for recovering alpha-alumina, also from clays.[34] In the first patent, the initial step involves prereducing an ore-coal or coke mixture at temperatures from 1,500° C to 1,800° C. The second step transfers the prereduced product to an electric furnace, where it is fluxed and heated to between 2,000° C and 2,300° C, converting the silicon carbide to silicon and the alumina to aluminum metal. The second patent details treating a calcined clay with hot nitric acid, resulting in a leach liquor containing less than 0.05% by weight of silica contaminant. The silica and other impurities are removed from the leach liquors by combined flocculation and solvent extraction steps. A purified hydrated aluminum nitrate is subsequently crystallized and heated in a fluidized bed forming recyclable nitric acid vapors and a dried aluminum nitrate, which is calcined to an alpha-alumina.

High-gradient magnetic separation (HGMS), a new and promising technology presently applied only in cleaning kaolin clays, was the topic of a thorough article.[35] HGMS devices were being used by several Georgia kaolin companies in removing micron-size discoloring particles, mainly weakly magnetic, yellow iron oxide stained rutile grains, from kaolin slurries destined for glossy white paper coating. HGMS devices, available for licensing to the clay industry by J. M. Huber Corp., were reportedly making available kaolin reserves which previously could not be beneficiated economically. The commercial-scale continuous attrition grinding of coarse paper filler kaolins to the finer paper-coating grades was reported by the Bureau of Mines.[36] A 20-inch-diameter grinding system was described along with optimized operating parameters. The role of kaolin in water-based latex paints, with emphasis on TiO_2 substitution, was reviewed.[37] The market

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31 Mining Magazine (London). V. 129, No. 3, September 1973, pp. 203–204.

32 McMinn. C. J., V. L. Bullough, and T. W. Williams (assigned to Reynolds Metal Co.). Direct Reduction of Titanium-Containing Bauxite or Clay in an Electrolytic Cell. Brit. Pat. 1,306,815, Feb. 14, 1973.

33 Wood, J. M., Jr. (assigned to Ethyl Corp.). Prereduction Process. U.S. Pat. 3,758,289, Sept. 11, 1973.

34 Margolin, S. V., and R. W. Hyde (assigned to Arthur D. Little, Inc.). Extraction of Pure Alpha-Alumina From Kaolin or Other Aluminous Clay. Brit. Pat. 1,311,614, Mar. 28, 1973.

35 Chemical and Engineering News Technology. V. 52, No. 4, Jan. 28, 1974, pp. 21–22.

36 Davis, E. G., E. W. Collins, and I. L. Feld. Large-Scale Continuous Attrition Grinding of Coarse Kaolins. BuMines RI 7771, 1973, 22 pp.

37 Adrien, D. O. Advances in Aluminum Silicates No Surprise to Many. Am. Paint Conv. Daily, v. 58, No. 18, Nov. 13, 1973, p. 31.

growth for clay and nonclay extender and filler pigments in the North Atlantic countries was forecast.[38]

A comprehensive article on the structures and compositions of clay materials, clay-water-exchange cation relations, and the thermal behavior of clay minerals and clay materials was published.[39] The reaction rates of aqueous phosphate solutions with kaolinite and alumina were detailed in another work.[40] The kinetics obeyed a first-order rate law probably involving nucleation and growth of a hexagonal $AlPO_4$ phase. The research gives an insight into the high phosphorous-binding capacity of sediments, eventually leading to the more efficient removal of phosphate pollutants from streams. Phosphorus has long been recognized as one of the main nutrients which accelerates eutrophication. The orientation of the hydroxyl ion in kaolinite, dickite, and nacrite was determined.[41] This work should contribute to the more efficient calcining of kaolins which are widely used in refractories, in ceramics, and as fillers and extenders. The dehydroxylization of kaolins is also the primary step in "opening-up" many clays for recovery of their alumina. The Gibbs free energies of formation of kaolinites, flint clays, illites, calcium, and sodium montmorillonites (nonswelling and swelling bentonites) were also determined from experimental work.[42] These data will permit more meaningful thermodynamic calculations for existing and predicted pyrogenic processes involving clays. An X-ray diffraction study of montmorillonites revealed that heat-treated clays give a more reliable estimate of silicate layers per particle than the conventional organic-treatment methods.[43] Penetration of the montmorillonite layers by the organic glycol molecules, normally an indication of swelling and/or exchange capacity, was found to be subject to uncontrolled variables which could lead to misleading results. Heat treatment combined with X-ray diffractometry was shown to give a more accurate measure of the silicate layers. The study of transmission[44] electron images coupled with selected area electron diffractometry revealed the presence of fine-grained micas in Camp Berteaux Moroccan bentonites. The study also showed the Wyoming bentonites were better crystallized, of larger crystalline size, and relatively free of the mica contaminants found in the Moroccan bentonites. The Moroccan bentonites also were reported to contain minor amounts of chlorite and kaolinite.

A detailed article on fuller's earth in England and the European bentonite industry was published.[45] The fuller's earth discussion dealt with Laporte Industries Ltd. sodium and calcium bentonites and activated earth operations at Redhill, Cockley, and Copyhold. The article also stressed new marketing areas, largely in civil engineering, and in animal feeds, absorbents, and insecticides. The Redhill mining operation supplies the Cockley works which produces the firm's acid-activated earths. The Copyhold facilities prepare the natural and exchanged clays. A concise account of the two acid activating processes—sulfuric and hydrochloric—used at Cockley and the sodium-exchange works at Copyhold, including their "Laponite" production—a synthetic hectorite—was also detailed. The bentonite portions covered the geology, mining and processing techniques, technological advances, environmental problems, markets, products, and future of the industry in Bavaria, West Germany; Ponza, Italy; and elsewhere in Europe and the Mediterranean. A similar article on bentonites in the United States was published.[46]

The role of bentonite in pelletizing iron ores was investigated thoroughly. This investigation was primarily to either reduce the quantity or find suitable alternatives to

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[38] American Paint Journal. V. 58, No. 15, Oct. 29, 1973, pp. 52–53.

[39] Brindley, G. W. The World of Clay Minerals. Bull. Am. Ceram. Soc., v. 52, No. 12, December 1973, pp. 892–895.

[40] Chen, Y. S. R. Kinetic Study of Phosphate Reactions With Aluminum Oxide and Kaolinite. Environmental Sci. and Technol., v. 7, No. 4, April 1973, pp. 327–332.

[41] Giese, R. F., Jr., and P. Data. Hydroxyl Orientation in Kaolinite, Dickite, and Nacrite. Am. Mineralogist, v. 58, Nos. 5–6, May 1973, pp. 471–479.

[42] Huang, W. H., and W. D. Keller. Gibbs Free Energies of Formation Calculated From Dissolution Data Using Specific Mineral Analyses, III. Clay Minerals. Am. Mineralogist, v. 58, Nos. 11/12, November/December 1973, pp. 1023–1028.

[43] Tettenhorst, R, and H. E. Roberson. H-Ray Diffraction Aspects of Montmorillonites. Am. Mineralogist, v. 58, Nos. 1–2, January/February, 1973, pp. 73–80.

[44] Güven, N. Montmorillonite: Electron-Optical Observations. Science, v. 181, No. 4104, Sept. 14, 1973, pp. 1049–1051.

[45] Industrial Minerals. No. 64, January 1973, pp. 9–34.

[46] Industrial Minerals. No. 66, March 1973, pp. 9–17.

Wyoming bentonites.[47] The influences of wet and dry strengths, drying rates, pellet porosity and moisture level were obtained from carefully prepared sized particles and interpreted in terms of the physical and chemical characteristics of United States, Western Australian, and New Zealand bentonites. The iron ore in this research was a hematitic ore from Koolen Island, Western Australia. Wyoming bentonites produced the highest green and dry strengths, enabling more efficient operations and high drying temperatures. Suppression and control of spontaneous combustion in English coal mines was controlled with bentonite slurry injections.[48]

A detailed discussion of the Western European refractory industry, both clay and nonclay raw materials, finished refractory goods, fired bricks and shapes, and monolithics, by country, was highlighted.[49] The discussion dealt with many individual companies. A similar in-depth study of the refractory industry in Japan was detailed in another article.[50] Selection of refractory rotary kiln linings consistent with a continuous increase in portland cement clinker output and a decrease in heat consumption was treated exhaustively.[51] Another comprehensive work on the performance of fire clay and high-alumina refractories in the sliding gate method of metal pouring was published.[52] Substantial savings on refractory costs were realized with fire clay and other lower alumina content nozzles.

A concise article on moving and renovating a fly ash sintering plant into an expanded shale operation was published.[53] The article included a flowsheet for the renovated plant. Another paper on preparing expanded shale aggregates for agricultural uses was published.[54] Comparative tests showed that expanded shales outperformed all other materials, such as perlite, vermiculite, peat, sand, sawdust, and styrofoam, as a rooting medium. The expanded shales were particularly effective in well-drained areas. Mineralogy and geochemistry of Pennsylvanian shales and underclays were correlated with their suitability for lightweight aggregate and refractory ladle brick at the Fall meeting of the AIME.[55]

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[47] Nicol, S. K., and Z. P. Adamiak. Role of Bentonite in Wet Pelletizing Processes. Inst. Min. and Met. Trans. (Sec. C), v. 82, No. 796, March 1973, C26–C33.

[48] Mining Journal (London). V. 282, No. 7227, Feb. 22, 1974, p. 135.

[49] Industrial Minerals. No. 65, February 1973, pp. 9–27.

[50] Industrial Minerals. No. 67, April 1973, pp. 9–19.

[51] Kunnecke, M., and B. Piscaer. Choosing Insulation for Rotary Kilns? Rock Products, v. 76, No. 5, May 1973, pp. 138–142, 148, 179.

[52] Keitch, J. A., and R. L. Stanford. Slide Gate Refractory Applications. J. of Metals, v. 25, No. 7, July 1973, pp. 38–42.

[53] Stearn, E. W. Sintering Plant Thrives After a 300-Mile Move. Rock Products, v. 76, No. 2, February 1973, pp. 80–81, 99.

[54] Stearn, E. W. Lightweight Aggregate Expands Horizons. Rock Products, v. 76, No. 12, December 1973, pp. 64–65.

[55] Williams, E. G., R. R. Holbrook, E. W. Lithgow, and B. R. Wilson. Properties and Occurrence of Bloating Shales and Clays in the Pennsylvanian of Western Pennsylvania. Pres. at Fall Meeting, Soc. Min. Eng., AIME, Pittsburgh, Pa., Sept., 19–21, 1973, SME Preprint 73–H–336, 12 pp.

Coal—Bituminous and Lignite

By L. Westerstrom [1]

DOMESTIC PRODUCTION

Bituminous coal and lignite production declined from 595.4 million tons in 1972 to 591.7 million tons in 1973. In 1973, coal demand exceeded supply throughout the year. The coal industry at times was unable to provide coal for new customers, while regular customers drew heavily from inventories. The loss in production, despite a strong demand for coal, was caused by insufficient mine capacity, unauthorized work stoppages, lower productivity in underground mines, and unfavorable weather.

Underground production declined 4.8 million tons in 1973 while production from surface mines, strip and auger, increased 1.1 million tons. Production increased in Western States and in the major coal-producing States of Kentucky and Pennsylvania, but declined in Alabama, Illinois, Indiana, Ohio, Virginia, and West Virginia.

This survey includes all bituminous coal produced in the United States except that from mines that produced less than 1,000 tons per year. All quantity figures represent marketable coal and exclude washery and other refuse. Statistics are based upon detailed annual reports furnished by producers. For production not directly reported (chiefly that of small mines), data were obtained from the records of State mine departments, which have statutory authority to require such reports. Thus, complete coverage of all mines producing 1,000 tons per year or more is reported.

The weekly and monthly estimates of production, summarized in tables 6 and 7, are based upon railroad car-loadings of coal reported weekly by railroads, river shipments reported by the U.S. Army Corps of Engineers, reports from mining companies, and monthly production statements complied by local operator associations and State mine departments.

Employment declined from 149,300 men in 1972 to 148,100 men in 1973. Productivity was also lower in 1973, but the rate of decline was less than in the 4 previous years. The average output per man-day at all mines fell from 17.74 tons in 1972 to 17.58 tons in 1973. At underground mines, output declined from 11.91 tons to 11.66 tons; output at strip mines increased from 35.95 tons to 36.30 tons per man-day.

RESERVES AND RESOURCES

The United States has vast coal resources. The U.S. Geological Survey has identified, at depths of less than 3,000 feet, deposits containing nearly 1,600 billion tons of coal. An additional hypothetical coal resource of comparable size is surmised to exist on the basis of broad geologic knowledge and theory. The Bureau of Mines has evaluated the information on identified deposits in order to determine the quantity of coal available in relatively thick beds and near enough to the surface to mine at this time by conventional surface or underground methods.[2]

Tables 2, 3, and 4 summarize the quantity of in-place coals calculated under specified depth and thickness criteria, which has been termed the "reserve base" by the Bureau of Mines. Thickness criteria were 28 inches or more for bituminous coal and anthracite, and 60 inches or more for subbituminous coal and lignite. The maximum depth for all ranks except lignite was 1,000

[1] Industry economist, Division of Fossil Fuels—Mineral Supply.

[2] U.S. Bureau of Mines. Demonstrated Coal Reserve Base of the United States on January 1, 1974. Mineral Industry Survey, June 1974, 6 pp.

feet. Only lignite beds that can be mined by surface methods were included—generally those beds that occur at depths no greater than 120 feet. Some coalbeds that did not meet the depth and thickness criteria were included because they are presently being mined or it was judged that they could be mined commercially at this time. "Demonstrated" is a collective term for the sum of materials in both the measured and indicated reserve categories, as defined by the Bureau of Mines and Geological Survey. These categories are based upon a high degree of geologic identification and engineering evaluation. The quantity of coal that can be recovered economically and legally from the reserves base is termed "the coal reserve."

CONSUMPTION AND DISTRIBUTION

Consumption of bituminous coal and lignite in the United States increased 7.6%, primarily at electric utility and oven coke plants and at steel-rolling mills. The remaining principal consumers used less coal than in the previous year. Consumers drew heavily from stockpiles during the year, and at the end of December, inventories had been depleted by over 14 million tons.

Tables 40, 41, and 42 summarize the shipments of coal and lignite in 1973. Table 43 shows the quantitative changes, by geographic division, and States of destination from 1969 through 1973. The distribution data, by consumer use, does not necessarily conform to the consumption data because the latter represents actual use at consumers' facilities, whereas the distribution data represents shipments from mines, some of which were in transit or in consumers' storage. These distribution data are based on reports submitted quarterly to the Bureau of Mines by producers, sales agents, distributors, and wholesalers, who normally produce or sell 100,000 tons or more annually. Their reported tonnage accounted for 93% of the coal produced or shipped in 1973. To account for total industry shipments, estimates for the remaining shipments are included, based on data from the Federal Power Commission and other reliable coal statistical reporting agencies.

Additional details of bituminous coal and lignite distribution for 1973 are presented in a Bureau of Mines report.[3]

PRICES

The average f.o.b. mine value for all coal increased from $7.66 per ton in 1972 to $8.53 per ton in 1973. At underground mines, the average price of coal increased from $9.70 per ton in 1972 to $10.84 per ton in 1973. The average price of coal at strip mines increased from $5.48 to $6.11 per ton. Average rail freight charges on coal increased from $3.67 per ton in 1972 to only $3.71 per ton in 1973 despite substantial increases in railroad freight rates. The slight increase in rail costs for transporting coal reflected the increase in unit-train traffic of nearly 19 million tons at reduced freight rates.

FOREIGN TRADE

Less coal was shipped from eastern and midwestern coal-producing districts in 1973. Shipments from the Appalachian Region were 18 million tons less than in 1972; shipments from western Kentucky, Illinois, and Indiana were approximately 2 million tons below those of 1972. Total shipments from Western States increased nearly 14 million tons in 1973.

In 1973, the United States exported 52.9 million tons, 3.1 million tons less than in 1972. Japan maintained its position as the principal U.S. foreign market with a 36.3% share of total U.S. coal exports. Shipments of coal to Canada, Europe, and South America accounted for 30.7%, 26.9%, and 5.0%, respectively.

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[3] U.S. Bureau of Mines. Bituminous Coal and Lignite Distribution for Calendar Year 1973. Mineral Industry Survey, Apr. 12, 1974, 41 pp.

TECHNOLOGY

Coal research by the Bureau of Mines during 1973 showed increased emphasis on the conversion of coal to low-ash, low-sulfur fuels through either gasification or liquefaction. At the same time, continued effort was expended to improve the quality of the environment.

Work on the SYNTHANE pilot plant has progressed to approximately 70% completion. This process, developed by the Bureau, gasifies any kind of coal with oxygen and steam to produce substitute natural gas. Following completion of the pilot-plant, which was scheduled for December 1974, operation was expected to provide data essential for demonstrating the commercial feasibility of the process.

Favorable results were obtained in converting high-sulfur coal to low-sulfur by the SYNTHOIL process. In this process, coal slurried in recycle oil is propelled by a rapid, turbulent flow of hydrogen through a fixed-bed catalytic reactor at 840° F at pressures up to 4,000 pounds per square inch. Using cobalt molybdate catalyst, about 95% of the coal is transformed into an oil that is fluid at room temperature and is suitable for boiler plant fuel. Design of an 8-ton-per-day pilot plant is underway; construction was scheduled to start in 1975. In addition, a feasibility study of the process was completed by an outside engineering firm.

In related coal combustion studies, construction continued on the three-stage combustor, designed to produce low-ash, high-temperature gas suitable for use in open-cycle magneto hydrodynamic (MHD) power generation. This combustor could also be used as a source of low-Btu gas for firing boilers.

Treatment of dried lignite with oil was found to reduce the reactivity of very low-moisture lignite more effectively than similar treatment of lignite dried to a mid-moisture content. The deactivation of dried low-rank coals to permit safe shipment and storage is a major objective in upgrading low-rank coals by drying. Such results may help establish the commercial feasibility of the process.

Bureau research on coal preparation has resulted in the development of a two-stage pyrite flotation process, which in laboratory tests removed up to 90% of the pyrite contained in coal from the Lower Freeport seam. Recently, the Bureau entered a cooperative research program with a coal company to study the applicability of this process to a high-sulfur coal now being discarded as waste. The two-stage pyrite flotation process is also being considered by a major steel company for commercial application to remove sulfur from coal from the Pittsburgh coalbed.

Research during the year on the Bureau's COSTEAM process showed that ash recovered from easily liquefied coals can effectively catalyze the liquefaction of more refractory (difficult to liquefy) coals.

During the year the final report on the design to be used in constructing the wood-to-oil pilot plant was completed. This pilot plant is to be erected at the Albany Metallurgy Research Center, Albany, Oreg., and will be capable of converting 3 tons per day of wood chips to about 6 barrels of low-sulfur fuel oil.

In combustion research during the year, the combustion characteristics were determined for low-volatile (5%) chars prepared from Illinois and Utah coals. When the chars were fed to the 500-pound-per-hour pulverized-fuel-fired furnace at ambient temperature, supplemental fuel equivalent to 15% of the total thermal input was required to maintain stable flames. Preheating the primary air-char stream to 450°–500° F eliminated the supplemental fuel requirement.

Table 1.—Salient statistics of the bituminous coal and lignite industry in the United States

Item	1969	1970	1971	1972	1973
Production thousand short tons	560,505	602,932	552,192	595,386	591,738
Value thousands	$2,795,509	$3,772,662	$3,904,562	$4,561,983	$5,049,612
Consumption thousand short tons	507,275	515,619	494,862	516,776	556,022
Stocks at end of year:					
Industrial consumers and retail yards thousand short tons	80,482	92,275	89,985	r 116,500	102,200
Stocks on upper lake docks do	1,484	1,468	1,205	939	822
Exports[1] do	56,234	70,944	56,633	r 55,997	52,903
Imports[1] do	109	36	111	47	127
Price indicators, average per net ton:					
Cost of coking coal at merchant coke ovens	$10.75	r $12.27	r $15.26	r $17.67	$19.77
Railroad freight charge[2]	$3.10	$3.41	$3.70	$3.67	$3.71
Value f.o.b. mines (sold in open market)	$4.65	$5.89	$6.66	$7.35	$8.06
Value f.o.b. mines	$4.99	$6.26	$7.07	$7.66	$8.53
Method of mining:					
Hand-loaded underground thousand short tons	11,700	9,599	4,992	2,974	1,970
Mechanically loaded underground do	335,431	329,189	270,896	301,129	297,384
Percentage mechanically loaded	96.6	97.2	98.2	99.0	99.3
Percentage cut by machine	46.2	46.1	40.6	37.4	35.8
Mined by stripping thousand short tons	197,023	244,117	258,972	275,730	276,645
Percentage mined by stripping	35.2	40.5	46.9	46.3	46.8
Mined at auger mines thousand short tons	16,350	20,027	17,332	15,554	15,739
Percentage mined at auger mines	2.9	3.3	3.1	2.6	2.7
Mechanically cleaned thousand short tons	334,761	323,452	271,401	292,829	288,918
Percentage mechanically cleaned	59.7	53.6	49.1	49.2	48.8
Number of mines	5,118	5,601	5,149	4,879	4,744
Capacity at 280 days thousand short tons	694,000	740,000	736,000	741,000	730,000
Capacity at 235 days do	583,000	621,000	618,000	622,000	613,000
Average number of men working daily:[3]					
Underground mines	99,269	107,808	109,311	112,252	111,083
Strip mines	22,323	28,395	32,979	34,027	34,203
Auger mines	2,940	3,937	3,374	2,986	2,835
Total	124,532	140,140	145,664	149,265	148,121
Average number of days worked:[3]					
Underground mines	224	229	210	222	231
Strip mines	247	236	220	225	223
Auger mines	139	148	132	121	122
Total	226	228	210	225	227
Production per man per day:[3]					
Underground mines short tons	15.61	13.76	12.03	11.91	11.66
Strip mines do	35.71	35.96	35.69	35.95	36.30
Auger mines do	39.88	34.26	39.00	43.00	45.33
Total do	19.90	18.84	18.02	17.74	17.58

r Revised.
[1] Bureau of the Census, U.S. Department of Commerce.
[2] Interstate Commerce Commission.
[3] Estimates based on data supplied by Health and Safety Analysis Center, Mining Enforcement and Safety Administration.

Table 2.—Demonstrated coal reserve base[1] of the United States on January 1, 1974, by method of mining

(Million short tons)

State	Potential mining method: Underground	Potential mining method: Surface	Total
Alabama	1,798	1,184	2,982
Alaska	4,246	7,399	11,645
Arizona	--	350	350
Arkansas	402	263	665
Colorado	14,000	870	14,870
Georgia	1	--	1
Illinois	53,442	12,223	65,665
Indiana	8,949	1,674	10,623
Iowa	2,885	--	2,885
Kansas	--	1,388	1,388
Kentucky, Eastern	9,467	3,450	12,917
Kentucky, Western	8,720	3,904	12,624
Maryland	902	146	1,048
Michigan	118	1	119
Missouri	6,074	3,414	9,488
Montana	65,165	42,562	107,727
New Mexico	2,136	2,258	4,394
North Carolina	31	(2)	31
North Dakota	--	16,003	16,003
Ohio	17,423	3,654	21,077
Oklahoma	860	434	1,294
Oregon	1	(2)	1
Pennsylvania	29,819	1,181	31,000
South Dakota	--	428	428
Tennessee	667	320	987
Texas	--	3,272	3,272
Utah	3,780	262	4,042
Virginia	2,971	679	3,650
Washington	1,446	508	1,954
West Virginia	34,378	5,212	39,590
Wyoming	27,554	23,674	51,228
Total	297,235	136,713	433,948

[1] Includes measured and indicated categories as defined by the U.S. Bureau of Mines and the U.S. Geological Survey and represents 100% of the coal in place.
[2] Less than 1 million tons.

Table 3.—Demonstrated reserve base[1] of coals in the United States on January 1, 1974, potentially minable by underground methods

(Million short tons)

State	Anthracite	Bituminous	Sub-bituminous	Lignite	Total
Alabama	--	1,798	--	--	1,798
Alaska	--	--	4,246	--	4,246
Arkansas	96	306	--	--	402
Colorado	28	9,227	4,745	--	14,000
Georgia	--	1	--	--	1
Illinois	--	53,442	--	--	53,442
Indiana	--	8,949	--	--	8,949
Iowa	--	2,885	--	--	2,885
Kentucky, Eastern	--	9,467	--	--	9,467
Kentucky, Western	--	8,720	--	--	8,720
Maryland	--	902	--	--	902
Michigan	--	118	--	--	118
Missouri	--	6,074	--	--	6,074
Montana	--	1,384	63,781	--	65,165
New Mexico	2	1,527	607	--	2,136
North Carolina	--	31	--	--	31
Ohio	--	17,423	--	--	17,423
Oklahoma	--	860	--	--	860
Oregon	--	--	1	--	1
Pennsylvania	7,030	22,789	--	--	29,819
Tennessee	--	667	--	--	667
Utah	--	3,780	--	--	3,780
Virginia	138	2,833	--	--	2,971
Washington	--	251	1,195	--	1,446
West Virginia	--	34,378	--	--	34,378
Wyoming	--	4,524	23,030	--	27,554
Total	7,294	192,336	97,605	--	297,235

[1] Includes measured and indicated categories as defined by the U.S. Bureau of Mines and the U.S. Geological Survey and represents 100% of the coal in place.

Table 4.—Demonstrated reserve base[1] of coals in the United States on January 1, 1974, potentially minable by surface methods

(Million short tons)

State	Anthracite	Bituminous	Sub-bituminous	Lignite	Total
Alabama	--	157	--	1,027	1,184
Alaska	--	1,201	5,902	296	7,399
Arizona	--	--	350	--	350
Arkansas	--	231	--	32	263
Colorado	--	870	--	--	870
Illinois	--	12,223	--	--	12,223
Indiana	--	1,674	--	--	1,674
Kansas	--	1,388	--	--	1,388
Kentucky, Eastern	--	3,450	--	--	3,450
Kentucky, Western	--	3,904	--	--	3,904
Maryland	--	146	--	--	146
Michigan	--	1	--	--	1
Missouri	--	3,414	--	--	3,414
Montana	--	--	35,431	7,131	42,562
New Mexico	--	250	2,008	--	2,258
North Carolina	--	(2)	--	--	(2)
North Dakota	--	--	--	16,003	16,003
Ohio	--	3,654	--	--	3,654
Oklahoma	--	434	--	--	434
Oregon	--	(2)	(2)	--	(2)
Pennsylvania	90	1,091	--	--	1,181
South Dakota	--	--	--	428	428
Tennessee	--	320	--	--	320
Texas	--	--	--	3,272	3,272
Utah	--	262	--	--	262
Virginia	--	679	--	--	679
Washington	--	--	500	8	508
West Virginia	--	5,212	--	--	5,212
Wyoming	--	--	23,674	--	23,674
Total	90	40,561	67,865	28,197	136,713

[1] Includes measured and indicated categories as defined by the U.S. Bureau of Mines and the U.S. Geological Survey and represents 100% of the coal in place.
[2] Less than 1 million tons.

Table 5.—Annual average unit heat value of bituminous coal and lignite produced and consumed in the United States, 1955–73[1]

(British thermal units (Btu) per pound)

Year	Total production			Domestic consumption		
	Thousand short tons	Trillion Btu	Average Btu per pound	Thousand short tons	Trillion Btu	Average Btu per pound
1955	464,633	12,080	13,000	423,412	10,940	12,920
1956	500,874	13,013	12,990	432,858	11,142	12,870
1957	492,704	12,800	12,990	413,668	10,640	12,860
1958	410,446	10,663	12,990	366,703	9,366	12,770
1959	412,028	10,581	12,840	366,256	9,332	12,740
1960	415,512	10,662	12,830	380,429	9,693	12,740
1961	402,977	10,308	12,790	374,405	9,502	12,690
1962	422,149	10,782	12,790	387,774	9,826	12,670
1963	458,928	11,712	12,760	409,225	10,353	12,650
1964	486,998	12,418	12,750	431,116	10,899	12,640
1965	512,088	13,017	12,710	459,164	11,580	12,610
1966	533,881	13,507	12,650	486,266	12,205	12,550
1967	552,626	13,904	12,580	480,416	11,981	12,470
1968	545,245	13,664	12,530	498,830	12,401	12,430
1969	560,505	13,957	12,450	507,275	12,509	12,330
1970	602,932	14,820	12,290	515,619	12,488	12,110
1971	552,192	13,385	12,120	494,862	11,857	11,980
1972	595,386	14,319	12,025	516,776	12,273	11,875
1973	591,738	14,208	12,005	556,022	13,150	11,825

[1] Prior to 1973, the average heat content of the annual output of bituminous coal and lignite was measured at 13,100 Btu per pound. This value was based on an estimate made in 1949 (U.S. Bureau of Mines Information Circular 7538). In recent years, this heat value has not been representative of the average unit heat value of the total annual coal supply because of the large annual increases in utilization of coal of lower heat values by the electric utility industry. The annual production values shown in this table are weighted averages of known and estimated Btu values of coal shipments to each major consuming sector. They include, for example, the Btu value of coal consumed at electric utility generating plants as reported to the Federal Power Commission and compiled by the National Coal Association. Currently, electric utility plants account for 70% of total domestic coal consumption. The averages for U.S. consumption exclude shipments overseas and to Canada, the preponderance of which is of high Btu value metallurgical coal, thus accounting for the difference in values between total production and domestic consumption.

Table 6.—Production of bituminous coal and lignite in the United States, with estimates, by week

(Thousand short tons)

Week ended	Production 1972	Maximum number of working days	Average production per working day	Week ended	Production 1973	Maximum number of working days	Average production per working day
Jan. 8	11,696	6	1,949	Jan. 6	9,307	5	1,861
Jan. 15	12,125	6	2,021	Jan. 13	10,503	6	1,751
Jan. 22	11,691	6	1,949	Jan. 20	11,346	6	1,891
Jan. 29	12,015	6	2,003	Jan. 27	11,556	6	1,926
Feb. 5	11,645	6	1,941	Feb. 3	11,787	6	1,965
Feb. 12	11,712	6	1,952	Feb. 10	10,974	6	1,829
Feb. 19	12,069	6	2,012	Feb. 17	11,349	6	1,892
Feb. 26	11,502	6	1,917	Feb. 24	11,510	6	1,918
Mar. 4	10,999	6	1,833	Mar. 3	12,101	6	2,017
Mar. 11	11,462	6	1,910	Mar. 10	11,585	6	1,931
Mar. 18	11,838	6	1,973	Mar. 17	10,901	6	1,817
Mar. 25	12,466	6	2,078	Mar. 24	10,906	6	1,818
Apr. 1	12,010	5.3	2,266	Mar. 31	11,994	6	1,999
Apr. 8	12,483	6	2,081	Apr. 7	10,276	5	2,055
Apr. 15	12,190	6	2,032	Apr. 14	11,360	6	1,893
Apr. 22	12,469	6	2,078	Apr. 21	11,325	6	1,888
Apr. 29	12,672	6	2,112	Apr. 28	11,805	6	1,968
May 6	11,372	6	1,895	May 5	11,345	6	1,891
May 13	11,502	6	1,917	May 12	11,229	6	1,872
May 20	11,990	6	1,998	May 19	11,595	6	1,933
May 27	12,125	6	2,021	May 26	11,527	6	1,921
June 3	10,765	5	2,153	June 2	10,672	5	2,134
June 10	13,206	6	2,201	June 9	12,090	6	2,015
June 17	13,191	6	2,199	June 16	12,781	6	2,130
June 24	12,521	6	2,087	June 23	12,650	6	2,108
July 1	6,624	3.1	2,137	June 30	6,377	3.1	2,057
July 8	4,438	2.1	2,113	July 7	4,626	2.3	2,011
July 15	10,475	4.8	2,182	July 14	10,664	5.2	2,051
July 22	11,605	6	1,934	July 21	11,938	6	1,990
July 29	11,889	6	1,982	July 28	12,025	6	2,004
Aug. 5	11,340	6	1,890	Aug. 4	11,917	6	1,986
Aug. 12	11,900	6	1,983	Aug. 11	12,415	6	2,069
Aug. 19	11,419	6	1,903	Aug. 18	12,042	6	2,007
Aug. 26	11,002	6	1,834	Aug. 25	12,350	6	2,058
Sept. 2	11,604	6	1,934	Sept. 1	12,327	6	2,055
Sept. 9	10,289	5	2,058	Sept. 8	10,147	5	2,029
Sept. 16	11,966	6	1,994	Sept. 15	12,196	6	2,033
Sept. 23	12,280	6	2,047	Sept. 22	12,582	6	2,097
Sept. 30	11,966	6	1,994	Sept. 29	12,784	6	2,131
Oct. 7	11,569	6	1,928	Oct. 6	11,862	6	1,977
Oct. 14	12,120	6	2,020	Oct. 13	11,959	6	1,993
Oct. 21	11,702	5	2,340	Oct. 20	11,911	5	2,382
Oct. 28	11,773	6	1,962	Oct. 27	11,989	6	1,998
Nov. 4	11,899	6	1,983	Nov. 3	11,745	6	1,958
Nov. 11	11,914	6	1,986	Nov. 10	12,048	6	2,008
Nov. 18	12,042	6	2,007	Nov. 17	11,502	6	1,917
Nov. 25	10,177	5	2,035	Nov. 24	10,298	5	2,060
Dec. 2	11,637	6	1,940	Dec. 1	11,524	6	1,921
Dec. 9	11,620	6	1,937	Dec. 8	13,149	6	2,192
Dec. 16	10,850	6	1,808	Dec. 15	13,082	6	2,180
Dec. 23	10,541	6	1,757	Dec. 22	11,653	6	1,942
Dec. 30	9,028	5	1,806	Dec. 29	8,229	5	1,646
				Jan. 5	[1]1,923	[2]1	[1]1,923
Total or average[3]	595,386	298.3	1,996		591,738	298.6	1,982

[1] Figures represent production and number of working days in that part of week included in calendar year shown.
[2] Average daily output for the working days in the calendar year shown.
[3] Data may not add to totals shown because of independent rounding.

Table 7.—Production of bituminous coal and lignite, in 1973, by State, with estimates by months[1]

(Thousand short tons)

States	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Alabama	1,646	1,562	1,754	1,559	1,629	1,374	1,511	1,774	1,578	1,783	1,666	1,394	19,230
Alaska	62	59	64	55	59	50	80	58	56	54	50	47	694
Arizona	250	219	292	276	255	282	273	311	249	305	292	243	3,247
Arkansas	46	25	20	40	58	49	25	30	29	38	37	37	434
Colorado	525	500	502	492	556	465	362	644	505	568	567	547	6,233
Illinois	5,548	5,281	5,212	4,525	5,247	4,590	4,871	6,098	5,364	5,032	4,908	4,896	61,572
Indiana	1,760	1,876	2,255	2,138	2,239	2,073	1,808	2,929	2,449	2,178	1,905	1,643	25,253
Iowa	49	53	49	49	49	53	50	57	47	60	44	41	601
Kansas	88	82	96	99	75	97	86	98	101	97	92	75	1,086
Kentucky:													
Eastern	6,133	5,406	6,203	6,197	7,018	6,540	5,402	6,885	5,867	6,780	5,925	5,610	73,966
Western	4,733	4,232	4,544	4,307	4,575	4,821	4,138	4,693	4,084	4,864	4,536	4,152	53,679
Total	10,866	9,638	10,747	10,504	11,593	11,361	9,540	11,578	9,951	11,644	10,461	9,762	127,645
Maryland	129	129	159	142	142	161	104	119	124	202	217	161	1,789
Missouri	357	284	319	252	313	338	345	643	442	513	474	378	4,658
Montana:													
Bituminous	662	667	832	730	780	733	606	1,016	925	1,175	1,184	1,101	10,411
Lignite	20	20	25	22	24	22	18	31	27	35	36	33	313
Total	682	687	857	752	804	755	624	1,047	952	1,210	1,220	1,134	10,724
New Mexico	498	534	757	606	612	588	685	1,168	841	1,003	1,039	738	9,069
North Dakota (lignite)	624	638	662	624	622	583	383	534	499	608	579	550	6,906
Ohio	3,852	3,743	3,917	3,790	4,254	3,800	3,603	4,196	3,673	4,017	3,732	3,206	45,783
Oklahoma	152	141	136	174	179	158	155	230	216	259	210	173	2,183
Pennsylvania	6,803	6,261	6,710	6,052	6,601	5,602	5,552	6,707	6,197	7,184	6,512	6,222	76,403
Tennessee	677	665	574	585	792	804	444	641	635	844	840	718	8,219
Texas	390	370	380	375	400	455	798	834	684	838	802	618	6,944
Utah	449	563	473	455	473	477	323	524	409	474	430	450	5,500
Virginia	2,836	2,581	2,882	2,920	3,095	2,633	2,443	3,257	2,725	3,158	2,837	2,594	33,961
Washington	225	261	249	274	284	279	317	312	297	274	261	237	3,270
West Virginia	10,019	9,013	10,467	9,265	10,093	8,391	8,257	10,732	9,016	10,271	8,822	11,102	115,448
Wyoming	846	728	1,014	996	996	1,195	1,162	1,353	1,299	1,768	1,829	1,700	14,886
Total	49,379	45,893	50,547	46,999	51,420	46,613	43,801	55,874	48,338	54,382	49,826	48,666	591,738

[1] Figures are based principally upon railroad carloadings and river shipments supplemented by direct reports from certain local sources. These estimates include coal both shipped by truck, and used at the mines, and the totals represent output for all mines producing 1,000 tons or more per year.

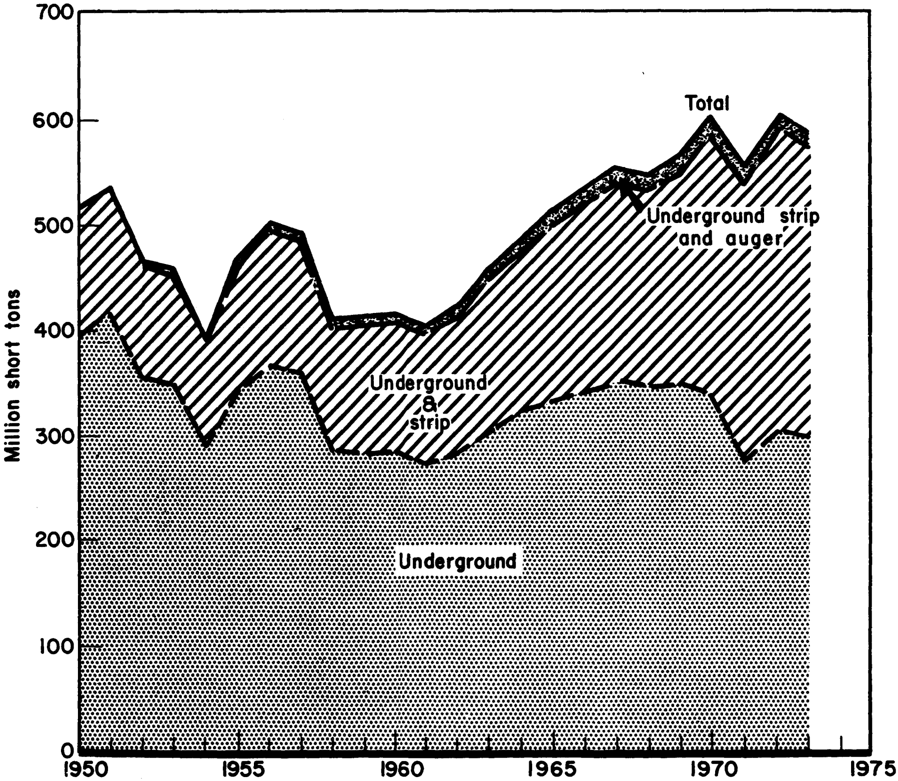

Figure 1.—Production of bituminous coal and lignite, by type of mining in the United States.

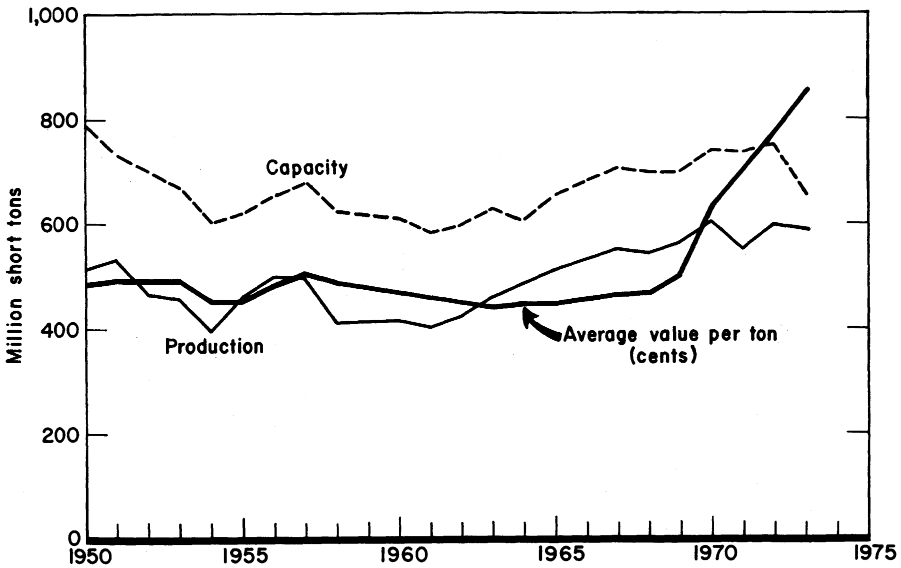

Figure 2.—Trends of bituminous coal and lignite production, realization, and mine capacity in the United States.

Table 8.—Production of bituminous coal and lignite in the United States, in 1973, by State, and type of mining

(Thousand short tons)

State	Underground	Strip	Auger	Total[1]
Alabama	7,618	11,529	84	19,230
Alaska	--	694	--	694
Arizona	--	3,247	--	3,247
Arkansas	3	432	--	434
Colorado	3,361	2,834	38	6,233
Illinois	32,570	29,002	--	61,572
Indiana	789	24,465	--	25,253
Iowa	356	245	--	601
Kansas	--	1,086	--	1,086
Kentucky:				
Eastern	40,553	23,671	9,742	73,966
Western	22,342	31,337	--	53,679
Total	62,895	55,008	9,742	127,645
Maryland	66	1,643	79	1,789
Missouri	--	4,658	--	4,658
Montana:				
Bituminous	1	10,410	--	10,411
Lignite	--	314	--	314
Total	1	10,724	--	10,725
New Mexico	733	8,336	--	9,069
North Dakota (lignite)	--	6,906	--	6,906
Ohio	16,225	28,527	1,031	45,783
Oklahoma	--	2,183	--	2,183
Pennsylvania	46,207	29,829	366	76,403
Tennessee	3,636	4,236	348	8,219
Texas (lignite)	--	6,944	--	6,944
Utah	5,500	--	--	5,500
Virginia	23,437	8,700	1,824	33,961
Washington	16	3,254	--	3,270
West Virginia	95,516	17,704	2,228	115,448
Wyoming	425	14,461	--	14,886
Grand total[1]	299,353	276,645	15,739	591,738

[1] Data may not add to totals shown because of independent rounding.

Table 9.—Production of bituminous coal and lignite in the United States, in 1973, by district, and by type of mining

(Thousand short tons)

District	Underground	Strip'	Auger	Total[1]
1. Eastern Pennsylvania	21,100	25,061	285	46,445
2. Western Pennsylvania	26,728	7,043	161	33,932
3. Northern West Virginia	25,563	8,454	431	34,447
4. Ohio	16,225	28,527	1,031	45,783
5. Michigan	--	--	--	--
6. Panhandle	8,711	120	22	8,853
7. Southern Number 1	27,067	2,836	493	30,395
8. Southern Number 2	99,592	41,848	13,174	154,614
9. West Kentucky	22,342	31,337	--	53,679
10. Illinois	32,570	29,002	--	61,572
11. Indiana	789	24,465	--	25,253
12. Iowa	356	245	--	601
13. Southeastern	8,273	11,951	105	20,329
14. Arkansas-Oklahoma	3	773	--	776
15. Southwestern	--	14,528	--	14,528
16. Northern Colorado	510	--	--	510
17. Southern Colorado	3,584	3,026	38	6,648
18. New Mexico	--	11,391	--	11,391
19. Wyoming	425	14,461	--	14,886
20. Utah	5,500	--	--	5,500
21. North-South Dakota	--	6,906	--	6,906
22. Montana	1	10,724	--	10,725
23. Washington	16	3,948	--	3,964
Total[1]	299,353	276,645	15,739	591,738

[1] Data may not add to totals shown because of independent rounding.

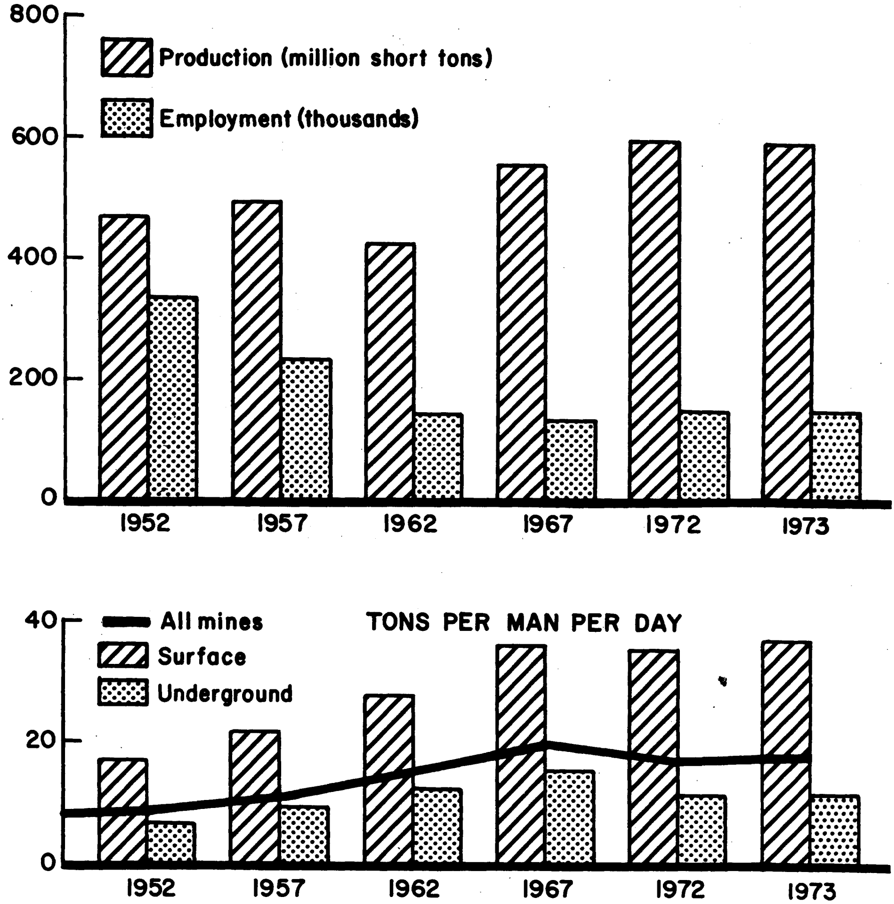

Figure 3.—Trends of employment and output per man at bituminous coal and lignite mines in the United States.

Table 10.—Number of mines, production, value, men working daily, days active, man-days, and output per man per day at bituminous coal and lignite mines in the United States, in 1973, by State

State	Number of active mines	Production (thousand short tons): Shipped by rail or water [1]	Production: Shipped by truck	Production: Mine-mouth generating plants	Production: All others [2]	Production: Total [3]	Average value per ton [4]	Average number of men working daily	Average number of days worked	Number of man-days worked (thousands)	Average tons per man per day
Alabama	105	14,304	3,003	1,915	8	19,230	$11.01	5,098	239	1,218	15.79
Alaska	1	579	115	--	--	694	W	74	277	20	33.86
Arizona	1	--	--	--	3,247	3,247	W	161	297	48	67.90
Arkansas	11	414	20	--	(5)	434	13.37	157	224	35	12.35
Colorado	30	4,853	746	630	4	6,233	7.41	1,418	252	357	17.46
Illinois	55	53,711	3,393	4,899	70	61,572	6.71	10,500	249	2,613	23.56
Indiana	39	21,129	3,682	411	31	25,253	6.06	2,680	262	702	35.98
Iowa	12	161	439	--	--	601	5.46	128	221	28	21.20
Kansas	4	1,009	74	--	3	1,086	7.35	228	294	67	16.20
Kentucky:											
Eastern	1,362	69,071	4,729	--	167	73,966	9.03	20,499	199	4,080	18.13
Western	81	43,584	1,365	8,707	23	53,679	5.98	7,476	256	1,916	28.02
Total [3]	1,443	112,655	6,094	8,707	190	127,645	7.73	27,975	214	5,996	21.29
Maryland	56	1,235	553	--	--	1,789	7.63	322	197	63	28.20
Missouri	10	1,260	90	3,307	--	4,658	5.37	579	265	158	30.39
Montana:											
Bituminous	7	10,339	22	--	50	10,411	2.83	270	292	79	132.26
Lignite	2	313	2	--	--	314	2.60	22	257	6	55.55
Total [3]	9	10,652	23	--	50	10,725	2.82	292	289	84	127.11
New Mexico	6	1,391	3	7,676	--	9,069	3.51	719	258	186	48.84
North Dakota (lignite)	12	3,705	50	2,998	153	6,906	2.07	265	255	67	102.36
Ohio	235	28,871	11,555	5,343	14	45,783	7.40	9,700	222	2,153	21.26
Oklahoma	11	2,060	122	--	1	2,183	7.69	380	290	110	19.82
Pennsylvania	964	51,223	17,824	7,246	110	76,403	10.30	25,373	240	6,102	12.52
Tennessee	119	5,601	2,618	--	--	8,219	8.13	1,934	207	400	20.54
Texas (lignite)	3	--	244	6,700	--	6,944	W	215	321	69	100.75
Utah	16	4,001	1,492	--	7	5,500	11.19	1,603	239	383	14.36
Virginia	650	32,673	1,285	--	3	33,961	11.12	12,226	220	2,685	12.65
Washington	3	--	24	3,246	--	3,270	6.56	318	264	84	38.90
West Virginia	932	105,174	3,776	6,188	311	115,448	11.61	44,765	218	9,762	11.83
Wyoming	17	9,100	45	5,658	84	14,886	4.09	1,011	263	266	55.94
Grand total [3]	4,744	465,762	57,268	64,424	4,284	591,738	8.53	148,121	227	33,653	17.58

W Withheld to avoid disclosing individual company confidential data.
[1] Includes coal loaded at mines directly into railroad cars or river barges, hauled by trucks to railroad siding, and hauled by trucks to waterways.
[2] Includes coal used at mine for power and heat, made into beehive coke at mine, used by mine employees, used for other purposes at mine, and shipped by slurry pipeline from Arizona.
[3] Data may not add to totals shown because of independent rounding.
[4] Value received or charged for coal, f.o.b. mine. Includes a value, estimated by producer, for coal not sold.
[5] Less than 500 tons.

Table 11.—Number of mines, production, value, men working daily, days active, man-days, and output per man per day at bituminous coal lignite mines in the United States, in 1973, by district

District	Number of active mines	Production (thousand short tons)					Average value per ton[4]	Average number of men working daily	Average number of days worked	Number of man-days worked (thousands)	Average tons per man per day
		Shipped by rail or water[1]	Shipped by truck	Mine-mouth generating plants	All others[2]	Total[3]					
1. Eastern Pennsylvania	740	26,999	12,127	7,246	73	46,445	$9.27	14,418	239	3,440	13.50
2. Western Pennsylvania	302	27,281	6,615	--	36	33,932	11.42	11,988	243	2,907	11.67
3. Northern West Virginia	249	30,888	1,883	1,543	134	34,447	9.03	9,977	211	2,102	16.38
4. Ohio	235	28,871	11,555	5,343	14	45,783	7.40	9,700	222	2,153	21.26
5. Michigan	--	--	--	--	--	--	--	--	--	--	--
6. Panhandle	16	4,194	325	4,290	44	8,853	8.86	2,827	231	652	13.58
7. Southern Number 1	321	29,279	1,010	--	106	30,395	15.73	15,020	219	3,297	9.22
8. Southern Number 2	2,436	145,352	8,710	355	196	154,614	10.08	50,555	210	10,621	14.56
9. West Kentucky	81	43,584	1,365	8,707	23	53,679	5.93	7,476	256	1,916	28.02
10. Illinois	55	53,711	3,393	4,399	70	61,572	6.71	10,500	249	2,613	23.56
11. Indiana	39	21,129	3,682	411	31	25,253	6.06	2,680	262	702	35.98
12. Iowa	12	161	439	--	--	601	5.46	128	221	28	21.20
13. Southeastern	124	15,288	3,118	1,915	8	20,329	10.88	5,432	238	1,290	15.76
14. Arkansas-Oklahoma	15	753	22	--	(5)	776	13.61	264	252	67	11.66
15. Southwestern	24	3,990	527	10,007	4	14,528	4.41	1,295	284	368	39.49
16. Northern Colorado	2	208	301	--	1	510	W	139	234	33	15.68
17. Southern Colorado	30	5,570	445	630	3	6,648	7.89	1,539	251	387	17.19
18. New Mexico	5	466	3	7,676	3,247	11,391	2.83	620	276	171	66.56
19. Wyoming	17	9,100	45	5,658	84	14,886	4.09	1,011	263	266	55.94
20. Utah	16	4,001	1,492	--	7	5,500	11.19	1,603	239	383	14.36
21. North-South Dakota	12	3,705	50	2,998	153	6,906	2.07	265	255	67	102.36
22. Montana	9	10,652	23	--	50	10,725	2.82	292	289	84	127.11
23. Washington	4	579	139	3,246	--	3,964	7.08	392	267	105	37.91
Total[3]	4,744	465,762	57,268	64,424	4,284	591,738	8.53	148,121	227	33,653	17.58

W Withheld to avoid disclosing individual company confidential data.
[1] Includes coal loaded at mines directly into railroad cars or river barges, hauled by trucks to railroad siding, and hauled by trucks to waterways.
[2] Includes coal used at mine for power and heat, made into beehive coke at mine, used by mine employees, used for other purposes at mine, and shipped by slurry pipeline in Arizona.
[3] Data may not add to totals shown because of independent rounding.
[4] Value received or charged for coal, f.o.b. mine. Includes a value, estimated by producer, for coal not sold.
[5] Less than 500 tons.

Table 12.—Number of mines, men working daily, days active, and output per man per day at bituminous coal and lignite mines in the United States, in 1973, by State

State	Number of mines			Average number of men working daily				Average number of days worked			Average tons per man per day			
	Underground	Strip	Auger	Underground	Strip	Auger	Total	Underground	Strip	Auger	Underground	Strip	Auger	Total
Alabama	21	83	1	3,274	1,818	6	5,098	235	246	260	9.91	25.76	53.61	15.79
Alaska	--	1	--	--	74	--	74	--	277	--	--	33.86	--	33.86
Arizona	--	1	--	--	161	--	161	--	297	--	--	67.90	--	67.90
Arkansas	1	10	--	5	152	--	157	109	228	--	4.60	12.47	--	12.35
Colorado	21	8	1	1,223	186	9	1,418	251	262	98	10.93	58.15	43.62	17.46
Illinois	23	32	--	7,229	3,271	--	10,500	249	248	--	18.07	35.80	--	23.56
Indiana	3	36	--	240	2,440	--	2,680	175	270	--	18.74	37.08	--	35.98
Iowa	2	10	--	53	75	--	128	292	171	--	22.98	19.06	--	21.20
Kansas	--	4	--	--	228	--	228	--	294	--	--	16.20	--	16.20
Kentucky:														
Eastern	584	399	379	14,868	4,153	1,478	20,499	215	164	139	12.70	34.75	47.46	18.13
Western	26	55	--	4,716	2,760	--	7,476	259	252	--	18.32	45.01	--	28.02
Total	610	454	379	19,584	6,913	1,478	27,975	225	199	139	14.25	39.94	47.46	21.29
Maryland	2	46	8	15	292	15	322	194	198	190	22.84	28.48	27.83	28.20
Missouri	--	10	--	--	579	--	579	--	265	--	--	30.39	--	30.39
Montana:														
Bituminous	1	6	--	5	265	--	270	52	296	--	4.06	132.68	--	132.26
Lignite	--	2	--	--	22	--	22	--	257	--	--	55.55	--	55.55
Total	1	8	--	5	287	--	292	52	293	--	4.06	127.50	--	127.11
New Mexico	1	5	--	239	480	--	719	239	268	--	12.82	64.86	--	48.84
North Dakota (lignite)	--	12	--	--	265	--	265	--	255	--	--	102.36	--	102.36
Ohio	28	176	31	5,982	3,587	131	9,700	228	216	114	11.89	36.88	69.15	21.26
Oklahoma	--	11	--	--	380	--	380	--	290	--	--	19.82	--	19.82
Pennsylvania	134	775	55	19,440	5,772	161	25,373	247	224	71	9.63	23.11	32.15	12.52
Tennessee	46	64	9	1,170	720	44	1,934	215	196	168	14.46	29.99	46.95	20.54
Texas (lignite)	--	3	--	--	215	--	215	--	321	--	--	100.75	--	100.75
Utah	16	--	--	1,603	--	--	1,603	239	--	--	14.36	--	--	14.36
Virginia	300	242	108	10,700	1,263	263	12,226	221	224	145	9.91	30.81	47.75	12.65
Washington	1	2	--	16	302	--	318	194	268	--	5.26	40.19	--	38.90
West Virginia	522	304	106	40,137	3,900	728	44,765	226	162	89	10.53	28.11	34.39	11.83
Wyoming	5	12	--	168	843	--	1,011	241	268	--	10.49	64.11	--	55.94
Grand total	1,737	2,309	698	111,083	34,203	2,835	148,121	231	223	122	11.66	36.30	45.33	17.58

Table 13.—Number of mines, men working daily, days active, and output per man per day at bituminous coal and lignite mines in the United States, in 1973, by District

District	Number of mines			Average number of men working daily				Average number of days worked			Average tons per man per day			
	Underground	Strip	Auger	Underground	Strip	Auger	Total	Underground	Strip	Auger	Underground	Strip	Auger	Total
1. Eastern Pennsylvania	87	611	42	9,387	4,914	117	14,418	243	233	85	9.24	21.87	28.57	13.50
2. Western Pennsylvania	53	228	21	10,533	1,396	59	11,988	250	172	72	10.14	26.25	37.63	11.67
3. Northern West Virginia	86	137	26	8,230	1,589	158	9,977	222	165	87	13.99	32.20	31.48	16.38
4. Ohio	28	176	31	5,982	3,587	131	9,700	228	216	114	11.89	36.88	69.15	21.26
5. Michigan	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6. Panhandle	8	7	1	2,790	34	3	2,827	232	141	133	13.47	25.00	54.38	13.58
7. Southern Number 1	223	67	31	14,149	733	138	15,020	223	173	91	8.57	22.41	39.22	9.22
8. Southern Number 2	1,119	774	543	41,001	7,351	2,203	50,555	221	171	131	10.97	33.26	45.71	14.56
9. West Kentucky	26	55	--	4,716	2,760	--	7,476	259	252	--	18.32	45.01	--	28.02
10. Illinois	23	32	--	7,229	3,271	--	10,500	249	248	--	18.07	35.80	--	23.56
11. Indiana	3	36	--	240	2,440	--	2,680	175	270	--	18.74	37.08	--	35.98
12. Iowa	2	10	--	53	75	--	128	292	171	--	22.98	19.06	--	21.20
13. Southeastern	33	89	2	3,514	1,901	17	5,432	234	244	138	10.05	25.74	45.08	15.76
14. Arkansas-Oklahoma	1	14	--	5	259	--	264	109	255	--	4.60	11.72	--	11.66
15. Southwestern	--	24	--	--	1,295	--	1,295	--	284	--	--	39.49	--	39.49
16. Northern Colorado	2	--	--	139	--	--	139	234	--	--	15.68	--	--	15.68
17. Southern Colorado	20	9	1	1,323	207	9	1,539	251	261	98	10.79	56.10	43.62	17.19
18. New Mexico	--	5	--	--	620	--	620	--	276	--	--	66.56	--	66.56
19. Wyoming	5	12	--	168	843	--	1,011	241	268	--	10.49	64.11	--	55.94
20. Utah	16	--	--	1,603	--	--	1,603	239	--	--	14.36	--	--	14.36
21. North-South Dakota	--	12	--	--	265	--	265	--	255	--	--	102.36	--	102.36
22. Montana	1	8	--	5	287	--	292	52	293	--	4.06	127.50	--	127.11
23. Washington	1	3	--	16	376	--	392	194	270	--	5.26	38.91	--	37.91
Total	1,737	2,309	698	111,083	34,203	2,835	148,121	231	223	122	11.66	36.30	45.33	17.58

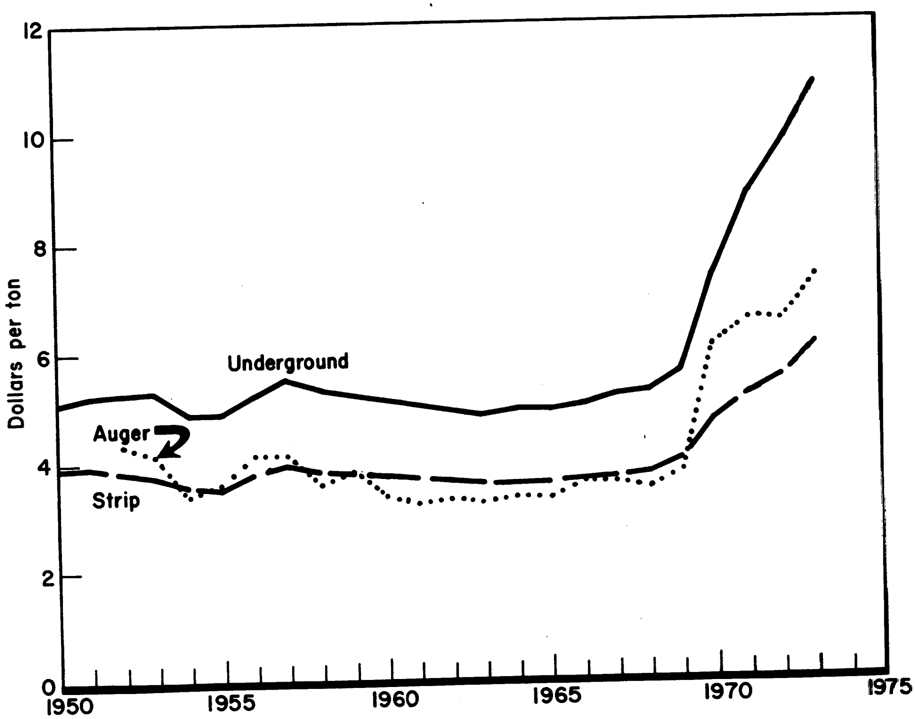

Figure 4.—Average value per ton f.o.b. mines, of bituminous coal and lignite produced in the United States, by type of mining.

Table 14.—Average value per ton, f.o.b. mines, of bituminous coal and lignite produced in the United States, by State

State	1972				1973			
	Underground	Strip	Auger	Total	Underground	Strip	Auger	Total
Alabama	$14.20	$7.01	$6.18	$9.63	$15.54	$8.04	$6.69	$11.01
Alaska	--	W	--	W	--	W	--	W
Arizona	--	W	--	W	--	W	--	W
Arkansas	12.50	10.90	--	10.93	13.89	13.36	--	13.37
Colorado	8.34	4.10	--	6.45	9.95	4.43	5.51	7.41
Illinois	6.83	5.49	--	6.14	7.52	5.81	--	6.71
Indiana	6.62	5.51	--	5.58	6.94	6.04	--	6.06
Iowa	4.80	4.91	--	4.86	5.40	5.54	--	5.46
Kansas	--	6.39	--	6.39	--	7.35	--	7.35
Kentucky:								
Eastern	9.46	6.23	6.20	8.01	10.63	7.05	7.22	9.03
Western	5.97	4.81	5.64	5.23	6.49	5.53	--	5.93
Total	8.31	5.38	6.20	6.81	9.16	6.18	7.22	7.73
Maryland	4.42	5.56	5.71	5.46	7.00	7.65	7.78	7.63
Missouri	--	5.20	--	5.20	--	5.37	--	5.37
Montana:								
Bituminous	9.74	2.00	--	2.01	16.81	2.82	--	2.83
Lignite	--	2.45	--	2.45	--	2.60	--	2.60
Total	9.74	2.01	--	2.03	16.81	2.82	--	2.82
New Mexico	10.42	2.66	--	3.61	10.00	2.94	--	3.51
North Dakota (lignite)	--	2.02	--	2.02	--	2.07	--	2.07
Ohio	7.41	5.29	4.69	5.96	8.50	6.82	6.20	7.40
Oklahoma	15.00	7.01	--	7.28	--	7.69	--	7.69
Pennsylvania	10.39	6.86	6.37	9.14	12.02	7.68	6.91	10.30
Tennessee	7.56	6.83	7.70	7.23	8.61	7.69	8.52	8.13
Texas (lignite)	--	W	--	W	--	W	--	W
Utah	8.93	8.00	--	8.93	11.19	--	--	11.19
Virginia	11.56	6.70	6.46	10.11	12.70	7.66	7.33	11.12
Washington	16.40	6.51	--	6.61	17.74	6.50	--	6.56
West Virginia	10.90	7.54	7.95	10.31	12.24	8.58	8.66	11.61
Wyoming	4.89	3.69	--	3.74	7.07	4.01	--	4.09
Total	9.70	5.48	6.54	7.66	10.84	6.11	7.39	8.53

W Withheld to avoid disclosing individual company confidential data.

Table 15.—Average value per ton, f.o.b. mines, of bituminous coal and lignite produced, by district

District	1972				1973			
	Underground	Strip	Auger	Total	Underground	Strip	Auger	Total
1. Eastern Pennsylvania	$9.60	$6.92	$6.66	$8.25	$11.05	$7.80	$6.74	$9.27
2. Western Pennsylvania	10.79	6.38	5.34	9.93	12.53	7.28	7.63	11.42
3. Northern West Virginia	8.55	6.84	6.36	8.16	9.60	7.37	7.85	9.03
4. Ohio	7.41	5.29	4.69	5.96	8.50	6.82	6.20	7.40
5. Michigan	--	--	--	--	--	--	--	--
6. Panhandle	7.51	6.50	6.50	7.49	8.88	7.57	7.57	8.86
7. Southern Number 1	14.87	11.40	11.88	14.45	16.12	12.77	11.01	15.73
8. Southern Number 2	10.19	6.41	6.47	8.86	11.56	7.41	7.35	10.08
9. West Kentucky	5.97	4.81	5.64	5.23	6.49	5.53	--	5.93
10. Illinois	6.83	5.49	--	6.14	7.52	5.81	--	6.71
11. Indiana	6.62	5.51	--	5.58	6.94	6.04	--	6.06
12. Iowa	4.80	4.91	--	4.86	5.40	5.54	--	5.46
13. Southeastern	13.40	6.98	6.18	9.43	15.07	8.02	6.75	10.88
14. Arkansas-Oklahoma	14.79	8.37	--	9.04	13.89	13.61	--	13.61
15. Southwestern	--	4.86	--	4.86	--	4.41	--	4.41
16. Northern Colorado	5.17	--	--	5.17	W	--	--	W
17. Southern Colorado	9.46	4.11	--	7.25	10.54	4.78	5.51	7.89
18. New Mexico	--	2.68	--	2.68	--	2.83	--	2.83
19. Wyoming	4.89	3.69	--	3.74	7.07	4.01	--	4.09
20. Utah	8.93	8.00	--	8.93	11.19	--	--	11.19
21. North-South Dakota	--	2.02	--	2.02	--	2.07	--	2.07
22. Montana	9.74	2.01	--	2.03	16.81	2.82	--	2.82
23. Washington	16.40	6.99	--	7.07	17.74	7.03	--	7.08
Total	9.70	5.48	6.54	7.66	10.84	6.11	7.39	8.53

Table 16.—Production and average value per ton, f.o.b. mines, of bituminous coal and lignite sold in open market and not sold in open market, by State

(Thousand short tons)

State	Production			Average value per ton, f.o.b. mines		
	Sold in open market	Not sold in open market	Total [1]	Sold in open market	Not sold in open market	Total
Alabama	15,226	4,004	19,230	$10.01	$14.79	$11.01
Alaska	694	--	694	W	--	W
Arizona	3,247	--	3,247	W	--	W
Arkansas	434	--	434	13.37	--	13.37
Colorado	4,954	1,279	6,233	5.32	15.50	7.41
Illinois	59,004	2,568	61,572	6.55	10.50	6.71
Indiana	25,253	--	25,253	6.06	--	6.06
Iowa	601	--	601	5.46	--	5.46
Kansas	1,086	--	1,086	7.35	--	7.35
Kentucky:						
Eastern	65,588	8,378	73,966	8.44	13.72	9.03
Western	53,679	--	53,679	5.93	--	5.93
Total	119,267	8,378	127,645	7.31	13.72	7.73
Maryland	1,789	--	1,789	7.63	--	7.63
Missouri	4,658	--	4,658	5.37	--	5.37
Montana:						
Bituminous	10,411	--	10,411	2.83	--	2.83
Lignite	1	313	314	6.50	2.58	2.60
Total	10,412	313	10,725	2.83	2.58	2.82
New Mexico	8,278	792	9,069	2.91	9.87	3.51
North Dakota (lignite)	5,003	1,903	6,906	2.00	2.26	2.07
Ohio	40,804	4,979	45,783	7.30	8.22	7.40
Oklahoma	1,993	190	2,183	6.99	15.04	7.69
Pennsylvania	52,929	23,474	76,403	8.71	13.88	10.30
Tennessee	8,219	--	8,219	8.13	--	8.13
Texas (lignite)	--	6,944	6,944	--	W	W
Utah	2,563	2,937	5,500	6.50	15.29	11.19
Virginia	33,003	958	33,961	11.00	15.30	11.12
Washington	24	3,246	3,270	14.10	6.50	6.56
West Virginia	103,214	12,234	115,448	11.13	15.62	11.61
Wyoming	11,277	3,609	14,886	4.31	3.40	4.09
Grand total [1]	513,929	77,808	591,738	8.06	11.65	8.53

W Withheld to avoid disclosing individual company confidential data.
[1] Data may not add to totals shown because of independent rounding.

Table 17.—Number and production of bituminous coal and lignite mines, in 1973, by State, size of output, and type of mining

(Thousand short tons)

State	500,000 tons and over		200,000 to 500,000 tons		100,000 to 200,000 tons		50,000 to 100,000 tons		10,000 to 50,000 tons		Less than 10,000 tons		Total [1]	
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity
Alabama:														
Underground	6	6,294	3	1,140	--	--	1	91	4	68	7	25	21	7,618
Strip	6	4,351	11	3,045	17	2,360	17	1,193	17	488	15	92	83	11,529
Auger	--	--	--	--	--	--	1	84	--	--	--	--	1	84
Total [1]	12	10,645	14	4,185	17	2,360	19	1,367	21	557	22	117	105	19,230
Alaska: Strip	1	694	--	--	--	--	--	--	--	--	--	--	1	694
Arizona: Strip	1	3,247	--	--	--	--	--	--	--	--	--	--	1	3,247
Arkansas:														
Underground	--	--	--	--	--	--	--	--	--	--	1	3	1	3
Strip	--	--	--	--	2	269	2	121	2	26	4	16	10	432
Total [1]	--	--	--	--	2	269	2	121	2	26	5	18	11	434
Colorado:														
Underground	2	1,279	4	1,063	6	896	--	--	5	100	4	23	21	3,361
Strip	3	2,408	--	--	3	415	--	--	--	--	2	11	8	2,834
Auger	--	--	--	--	--	--	--	--	1	38	--	--	1	38
Total [1]	5	3,687	4	1,063	9	1,310	--	--	6	138	6	34	30	6,233
Illinois:														
Underground	18	31,937	1	424	--	--	2	159	2	51	--	--	23	32,570
Strip	18	26,749	5	1,937	--	--	4	269	2	29	3	18	32	29,002
Total	36	58,686	6	2,361	--	--	6	428	4	80	3	18	55	61,572
Indiana:														
Underground	1	614	--	--	--	--	2	174	--	--	--	--	3	789
Strip	12	22,618	4	1,091	3	340	2	118	11	282	4	16	36	24,465
Total [1]	13	23,232	4	1,091	3	340	4	292	11	282	4	16	39	25,253
Iowa:														
Underground	--	--	1	249	1	107	--	--	--	--	--	--	2	356
Strip	--	--	--	--	--	--	1	52	8	188	1	5	10	245
Total	--	--	1	249	1	107	1	52	8	188	1	5	12	601
Kansas: Strip	1	725	1	213	1	140	--	--	--	--	1	7	4	1,086
Kentucky:														
Eastern:														
Underground	18	13,813	34	10,375	40	5,600	58	4,004	230	5,753	204	1,008	584	40,553
Strip	4	3,527	28	7,326	30	3,999	64	4,383	151	3,879	122	557	399	23,671
Auger	--	--	1	267	18	2,504	27	1,999	180	4,284	153	688	379	9,742
Total	22	17,340	63	17,968	88	12,103	149	10,386	561	13,916	479	2,253	1,362	73,966
Kentucky:														
Western:														
Underground	16	20,713	4	1,244	1	105	3	245	1	29	1	6	26	22,342

Strip	17	27,748	4	1,403	10	1,505	6	413	8	209	10	58	55	31,337
Total [1]	33	48,462	8	2,647	11	1,610	9	658	9	238	11	64	81	53,679
Total Kentucky:														
Underground	34	34,526	38	11,619	41	5,705	61	4,249	231	5,782	205	1,014	610	62,895
Strip	21	31,276	32	8,729	40	5,504	70	4,796	159	4,088	132	615	454	55,008
Auger	--	--	1	267	18	2,504	27	1,999	180	4,284	153	688	379	9,742
Total [1]	55	65,802	71	20,616	99	13,713	158	11,044	570	14,154	490	2,317	1,443	127,645
Maryland:														
Underground	--	--	--	--	--	--	1	62	--	--	1	5	2	66
Strip	--	--	--	--	3	464	8	601	20	501	15	76	46	1,643
Auger	--	--	--	--	--	--	--	--	1	34	7	45	8	79
Total [1]	--	--	--	--	3	464	9	663	21	535	23	126	56	1,789
Missouri: Strip	5	4,027	1	498	--	--	1	72	2	53	1	8	10	4,658
Montana:														
Underground	--	--	--	--	--	--	--	--	--	--	1	1	1	1
Strip	3	10,385	1	313	--	--	--	--	--	--	4	26	8	10,724
Total	3	10,385	1	313	--	--	--	--	--	--	5	27	9	10,725
New Mexico:														
Underground	1	733	--	--	--	--	--	--	--	--	--	--	1	733
Strip	1	7,325	2	814	1	192	--	--	--	--	1	5	5	8,336
Total	2	8,058	2	814	1	192	--	--	--	--	1	5	6	9,069
North Dakota: Strip	4	5,665	2	934	2	291	--	--	--	--	4	16	12	6,906
Ohio:														
Underground	15	15,275	2	576	1	122	2	131	4	98	4	23	28	16,225
Strip	13	15,240	15	4,838	27	3,990	38	2,675	55	1,610	28	173	176	28,527
Auger	--	--	--	--	3	403	4	301	14	279	10	47	31	1,031
Total	28	30,515	17	5,414	31	4,515	44	3,107	73	1,987	42	243	235	45,783
Oklahoma: Strip	2	1,557	--	--	3	424	2	138	2	58	2	5	11	2,183
Pennsylvania:														
Underground	39	34,401	26	8,534	14	1,864	14	930	15	351	26	127	134	46,207
Strip	2	1,256	5	1,311	55	6,340	112	7,405	459	12,743	142	774	775	29,829
Auger	--	--	--	--	--	--	--	--	9	143	46	224	55	366
Total [1]	41	35,657	31	9,845	69	8,204	126	8,335	483	13,236	214	1,125	964	76,403
Tennessee:														
Underground	1	1,231	3	832	1	150	11	792	22	589	8	41	46	3,636
Strip	--	--	4	810	11	1,500	18	1,282	22	593	9	50	64	4,236
Auger	--	--	--	--	--	--	2	128	6	211	1	8	9	348
Total [1]	1	1,231	7	1,642	12	1,650	31	2,203	50	1,394	18	99	119	8,219
Texas: Strip	2	6,700	1	244	--	--	--	--	--	--	--	--	3	6,944
Utah: Underground	3	2,324	7	2,698	3	387	--	--	3	91	--	--	16	5,500
Virginia:														
Underground	6	5,599	27	8,677	12	1,583	50	3,006	182	4,460	23	111	300	23,437
Strip	--	--	3	1,085	12	1,571	15	1,133	183	4,670	29	241	242	8,700
Auger	--	--	--	--	1	121	1	81	99	1,581	7	40	108	1,824
Total [1]	6	5,599	30	9,762	25	3,275	66	4,219	464	10,712	59	393	650	33,961

See footnote at end of table.

Table 17.—Number and production of bituminous coal and lignite mines, in 1973, by State, size of output, and type of mining—Continued

(Thousand short tons)

State	500,000 tons and over		200,000 to 500,000 tons		100,000 to 200,000 tons		50,000 to 100,000 tons		10,000 to 50,000 tons		Less than 10,000 tons		Total [1]	
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity
Washington:														
Underground	--	--	--	--	--	--	--	--	1	16	--	--	1	16
Strip	1	3,246	--	--	--	--	--	--	--	--	1	8	2	3,254
Total [1]	1	3,246	--	--	--	--	--	--	1	16	1	8	3	3,270
West Virginia:														
Underground	49	48,701	85	26,117	77	11,532	72	5,353	135	3,328	104	486	522	95,516
Strip	--	--	21	6,256	24	3,228	51	3,754	156	4,153	52	313	304	17,704
Auger	--	--	--	--	2	228	7	463	66	1,385	31	152	106	2,228
Total [1]	49	48,701	106	32,373	103	14,988	130	9,570	357	8,865	187	950	932	115,448
Wyoming:														
Underground	--	--	1	315	--	--	1	96	--	--	3	14	5	425
Strip	9	13,997	1	445	--	--	--	--	1	19	1	1	12	14,461
Total [1]	9	13,997	2	760	--	--	1	96	1	19	4	16	17	14,886
United States:														
Underground	175	182,914	198	62,244	156	22,346	217	15,043	604	14,934	387	1,873	1,737	299,353
Strip	105	161,466	109	32,563	204	27,028	341	23,609	1,099	29,501	451	2,476	2,309	276,645
Auger	--	--	1	267	24	3,256	42	3,056	376	7,955	255	1,204	698	15,739
Total [1]	280	344,380	308	95,074	384	52,629	600	41,707	2,079	52,391	1,093	5,553	4,744	591,738

[1] Data may not add to totals shown because of independent rounding.

Table 18.—Production, shipments, and value at bituminous coal and lignite mines, in 1973, by State and county

(Thousand short tons)

State and county	Production						Shipments					Average value per ton [4]
	Underground		Strip		Auger		Rail or water [1]	Truck	Mine-mouth generating plants	All other [2]	Total [3]	
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity						
Alabama:												
Bibb	--	--	2	828	--	--	768	60	--	--	828	$7.07
Blount	--	--	5	219	--	--	56	163	--	--	219	11.22
Cullman	--	--	9	767	--	--	333	434	--	--	767	6.99
Etowah	--	--	1	7	--	--	7	--	--	--	7	W
Fayette	1	21	--	--	--	--	21	--	--	--	21	W
Jackson	--	--	1	818	--	--	818	--	--	--	818	W
Jefferson	14	4,840	22	3,684	1	84	7,272	1,090	237	8	8,607	11.55
Marion	3	28	2	241	--	--	241	28	--	--	270	9.54
Shelby	--	--	1	106	--	--	106	--	--	--	106	7.21
Tuscaloosa	--	--	8	1,528	--	--	1,379	148	--	--	1,528	8.79
Walker	3	2,729	29	3,171	--	--	3,279	942	1,678	--	5,899	12.69
Winston	--	--	3	161	--	--	24	137	--	--	161	10.75
Total [3]	21	7,618	83	11,529	1	84	14,304	3,003	1,915	8	19,230	11.01
Alaska	--	--	1	694	--	--	579	115	--	--	694	W
Arizona: Navajo	--	--	1	3,247	--	--	--	--	--	3,247	3,247	W
Arkansas:												
Franklin	--	--	2	72	--	--	71	1	--	(5)	72	W
Johnson	1	3	3	167	--	--	169	--	--	--	169	13.89
Logan	--	--	2	19	--	--	--	19	--	--	19	W
Sebastian	--	--	3	174	--	--	174	--	--	--	174	14.00
Total	1	3	10	432	--	--	414	20	--	(5)	434	13.37
Colorado:												
Delta	2	212	--	--	--	--	207	5	--	--	212	W
Fremont	4	80	2	129	1	38	2	246	--	(5)	247	5.45
Garfield	1	1	--	--	--	--	--	1	--	--	1	W
Gunnison	3	846	--	--	--	--	806	39	--	(5)	846	11.79
La Plata	1	9	--	--	--	--	--	9	--	--	9	W
Las Animas	1	624	--	--	--	--	624	--	--	--	624	W
Moffat	2	290	--	--	--	--	263	27	--	(5)	290	W
Montrose	--	--	1	105	--	--	--	105	--	2	107	6.36
Pitkin	4	778	1	4	--	--	782	--	--	--	782	6.49
Routt	1	11	4	2,595	--	--	1,962	13	630	(5)	2,605	4.31
Weld	2	510	--	--	--	--	208	301	--	1	510	W
Total [3]	21	3,361	8	2,834	1	38	4,853	746	630	4	6,233	7.41
Illinois:												
Christian	1	4,147	--	--	--	--	1,161	370	2,612	3	4,147	6.57
Douglas	2	1,620	--	--	--	--	805	815	--	(5)	1,620	W
Franklin	3	6,482	--	--	--	--	6,458	24	--	(5)	6,482	6.71
Fulton	--	--	3	3,136	--	--	2,830	304	--	1	3,136	6.84
Gallatin	2	1,557	1	310	--	--	1,867	--	--	--	1,867	8.12

See footnotes at end of table.

Table 18.—Production, shipments, and value at bituminous coal and lignite mines, in 1973, by State and county—Continued

(Thousand short tons)

State and county	Production: Underground: Number of mines	Production: Underground: Quantity	Production: Strip: Number of mines	Production: Strip: Quantity	Production: Auger: Number of mines	Production: Auger: Quantity	Shipments: Rail or water [1]	Shipments: Truck	Shipments: Mine-mouth generating plants	Shipments: All other [2]	Shipments: Total [3]	Average value per ton [4]
Illinois—Continued												
Jackson	--	--	2	77	--	--	76	1	--	--	77	W
Jefferson	3	6,626	1	664	--	--	7,117	163	--	9	7,289	$8.89
Johnson	--	--	1	5	--	--	2	3	--	--	5	W
Kankakee	--	--	1	414	--	--	91	324	--	--	414	9.02
Knox	--	--	1	1,016	--	--	955	61	--	--	1,016	W
Macoupin	1	2,695	--	--	--	--	2,686	(5)	--	9	2,695	W
Mercer	1	12	1	6	--	--	6	12	--	--	18	W
Montgomery	1	1,888	--	--	--	--	--	145	1,742	--	1,888	W
Peoria	--	--	3	1,758	--	--	1,215	543	--	--	1,758	6.76
Perry	--	--	5	11,212	--	--	11,169	27	--	16	11,212	5.03
Randolph	2	2,014	2	2,833	--	--	4,578	268	--	(5)	4,847	6.20
St. Clair	1	2,354	2	4,297	--	--	6,651	--	--	--	6,651	5.58
Saline	2	1,391	4	1,098	--	--	2,322	118	44	4	2,488	8.18
Stark	--	--	1	379	--	--	379	--	--	(5)	379	W
Wabash	1	38	--	--	--	--	--	17	--	22	38	W
Williamson	3	1,747	4	1,799	--	--	3,344	197	--	4	3,546	7.95
Total [3]	23	32,570	32	29,002	--	--	53,711	3,393	4,399	70	61,572	6.71
Indiana:												
Clay	--	--	6	1,293	--	--	49	1,236	--	8	1,293	6.31
Fountain	--	--	1	39	--	--	--	39	--	--	39	W
Gibson	1	614	1	16	--	--	614	16	--	--	630	W
Greene	--	--	5	1,059	--	--	990	69	--	--	1,059	6.24
Parke	--	--	1	2	--	--	--	2	--	--	2	3.20
Pike	1	92	8	5,697	--	--	4,657	721	411	(5)	5,789	6.37
Spencer	--	--	3	542	--	--	475	67	--	--	542	5.13
Sullivan	--	--	3	4,252	--	--	3,557	694	--	2	4,252	6.39
Vermillion	--	--	1	3,044	--	--	3,044	--	--	--	3,044	4.96
Vigo	1	82	--	--	--	--	--	82	--	--	82	W
Warrick	--	--	7	8,520	--	--	7,743	756	--	21	8,520	5.99
Total [3]	3	789	36	24,465	--	--	21,129	3,682	411	31	25,253	6.06
Iowa:												
Lucas	1	107	--	--	--	--	--	107	--	--	107	W
Mahaska	--	--	4	135	--	--	56	79	--	--	135	5.38
Marion	--	--	4	64	--	--	59	5	--	--	64	5.47
Monroe	1	249	--	--	--	--	--	249	--	--	249	W
Wapello	--	--	2	46	--	--	46	--	--	--	46	6.10
Total [3]	2	356	10	245	--	--	161	439	--	--	601	5.46
Kansas:												
Cherokee	--	--	2	732	--	--	712	17	--	3	732	W
Crawford	--	--	2	353	--	--	297	57	--	--	353	W
Total [3]	--	--	4	1,086	--	--	1,009	74	--	3	1,086	7.35

Kentucky:												
Eastern:												
Bell	21	645	16	2,641	10	441	3,494	234	--	--	3,728	7.97
Boyd	--	--	4	152	2	17	109	60	--	--	169	6.60
Breathitt	--	--	36	4,585	31	1,769	6,227	127	--	--	6,354	7.50
Carter	--	--	4	71	--	--	30	41	--	--	71	7.38
Clay	5	145	6	175	5	208	498	30	--	--	528	7.34
Elliott	--	--	3	175	1	2	177	--	--	--	177	8.32
Floyd	103	2,393	23	1,219	28	792	4,014	390	--	--	4,404	7.24
Harlan	67	8,965	27	727	32	628	9,461	832	--	26	10,319	11.94
Jackson	--	--	1	2	--	--	--	2	--	--	2	W
Johnson	3	148	19	448	17	272	783	84	--	--	868	6.84
Knott	48	3,078	17	491	23	403	3,758	214	--	--	3,972	9.07
Knox	3	16	28	647	17	204	619	248	--	--	867	7.58
Laurel	--	--	13	230	9	76	273	33	--	--	306	7.68
Lawrence	--	--	5	222	3	94	294	23	--	--	317	6.53
Lee	1	20	--	--	--	--	14	6	--	--	20	W
Leslie	14	1,480	16	609	19	313	2,143	260	--	--	2,403	8.25
Letcher	59	3,132	23	1,004	28	638	4,386	383	--	4	4,774	8.52
McCreary	4	887	3	138	1	8	1,033	--	--	--	1,038	7.75
Magoffin	--	--	11	675	7	114	753	35	--	--	789	7.40
Martin	12	2,674	15	3,176	7	304	6,148	6	--	--	6,154	6.62
Morgan	--	--	2	127	1	6	19	115	--	--	133	7.69
Owsley	--	--	5	151	3	72	121	102	--	--	224	7.00
Perry	28	2,540	25	2,198	29	1,035	5,632	142	--	--	5,774	8.28
Pike	210	14,169	63	2,821	83	2,099	18,075	878	--	136	19,090	10.42
Pulaski	2	66	1	314	--	--	205	176	--	--	381	W
Rockcastle	--	--	1	6	1	3	--	10	--	--	10	W
Wayne	--	--	2	47	2	23	--	70	--	--	70	7.00
Whitley	4	194	30	618	20	219	805	226	--	--	1,031	7.90
Total [3]	584	40,553	399	23,671	379	9,742	69,071	4,729	--	167	73,966	9.03
Kentucky:												
Western:												
Butler	1	6	6	78	--	--	50	14	--	20	83	5.96
Christian	--	--	1	171	--	--	171	--	--	--	171	W
Daviess	--	--	1	977	--	--	350	--	627	--	977	W
Edmonson	--	--	1	96	--	--	93	--	--	3	96	W
Henderson	1	600	--	--	--	--	--	600	--	--	600	W
Hopkins	9	5,780	13	4,266	--	--	9,783	263	--	--	10,046	6.43
McLean	--	--	5	1,312	--	--	1,237	75	--	--	1,312	5.77
Muhlenberg	5	5,223	15	19,104	--	--	16,234	14	8,080	--	24,327	5.46
Ohio	3	2,192	12	5,302	--	--	7,125	369	--	--	7,493	5.83
Union	6	7,093	--	--	--	--	7,093	--	--	--	7,093	6.52
Webster	1	1,450	1	31	--	--	1,450	31	--	--	1,481	7.57
Total [3]	26	22,342	55	31,337	--	--	43,584	1,365	8,707	23	53,679	5.93
Total Kentucky	610	62,895	454	55,008	379	9,742	112,655	6,094	8,707	190	127,645	7.73
Maryland:												
Allegany	--	--	16	501	3	10	231	280	--	--	511	6.75
Garrett	2	66	30	1,142	5	69	1,004	273	--	--	1,277	7.98
Total [3]	2	66	46	1,643	8	79	1,235	553	--	--	1,789	7.63

See footnotes at end of table.

Table 18.—Production, shipments, and value at bituminous coal and lignite mines, in 1973, by State and county—Continued

(Thousand short tons)

State and county	Production						Shipments					Average value per ton [4]
	Underground		Strip		Auger		Rail or water [1]	Truck	Mine-mouth generating plants	All other [2]	Total [3]	
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity						
Missouri:												
Barton	--	--	1	600	--	--	--	--	600	--	600	W
Bates	--	--	1	969	--	--	--	--	969	--	969	W
Henry	--	--	2	1,726	--	--	468	30	1,228	--	1,726	$5.13
Howard	--	--	1	19	--	--	--	19	--	--	19	W
Macon	--	--	1	720	--	--	720	--	--	--	720	6.83
Putnam	--	--	1	72	--	--	72	--	--	--	72	W
Randolph	--	--	1	509	--	--	--	--	509	--	509	5.30
Vernon	--	--	2	42	--	--	--	42	--	--	42	W
Total [3]	--	--	10	4,658	--	--	1,260	90	3,307	--	4,658	5.37
Montana (bituminous):												
Big Horn	--	--	1	W	--	--	W	--	--	W	W	W
Musselshell	1	1	3	W	--	--	W	W	--	--	W	W
Rosebud	--	--	2	W	--	--	W	W	--	--	W	W
Total [3]	1	1	6	10,410	--	--	10,339	22	--	W	10,411	2.83
Montana (lignite):												
Powder River	--	--	1	1	--	--	--	1	--	--	1	W
Richland	--	--	1	313	--	--	313	(5)	--	--	313	W
Total [3]	--	--	2	314	--	--	313	2	--	--	314	2.60
Total Montana [3]	1	1	8	10,724	--	--	10,652	23	--	W	10,725	2.82
New Mexico:												
Colfax	1	733	1	192	--	--	925	--	--	--	925	W
McKinley	--	--	2	469	--	--	466	3	--	--	469	W
San Juan	--	--	2	7,676	--	--	--	--	7,676	--	7,676	W
Total [3]	1	733	5	8,336	--	--	1,391	3	7,676	--	9,069	3.51
North Dakota (lignite):												
Adams	--	--	1	1	--	--	--	1	--	--	1	5.00
Bowman	--	--	1	185	--	--	147	--	--	38	185	W
Burke	--	--	1	482	--	--	459	24	--	--	482	W
Grant	--	--	1	5	--	--	--	5	--	--	5	W
Mercer	--	--	3	4,101	--	--	2,647	10	1,435	9	4,101	2.15
Oliver	--	--	1	1,563	--	--	--	--	1,563	--	1,563	W
Stark	--	--	2	108	--	--	--	2	--	106	108	4.51
Ward	--	--	1	452	--	--	452	--	--	--	452	W
Williams	--	--	1	8	--	--	--	8	--	--	8	W
Total [3]	--	--	12	6,906	--	--	3,705	50	2,998	153	6,906	2.07
Ohio:												
Belmont	7	7,134	28	8,903	5	301	15,421	902	--	14	16,338	7.69
Carroll	--	--	4	245	1	19	--	192	72	(5)	265	7.00
Columbiana	3	34	17	746	5	72	94	757	--	(5)	852	5.91
Coshocton	1	774	9	1,693	1	68	345	801	1,389	--	2,535	8.46

Gallia	--	--	2	18	1	6	9	15	--	--	24	5.12
Guernsey	--	--	3	368	--	--	253	116	--	--	368	6.78
Harrison	4	3,744	11	3,460	1	113	6,876	441	--	--	7,316	7.81
Hocking	--	--	6	247	--	--	--	247	--	--	247	5.28
Holmes	--	--	7	622	1	14	--	636	--	--	636	5.93
Jackson	5	241	5	748	1	10	395	603	--	--	999	5.12
Jefferson	3	881	27	3,661	10	271	2,827	1,894	92	--	4,813	6.69
Lawrence	--	--	1	22	--	--	--	22	--	--	22	W
Mahoning	--	--	6	398	--	--	--	398	--	--	398	5.94
Meigs	2	358	--	--	--	--	--	44	314	--	358	W
Monroe	1	882	--	--	--	--	882	--	--	--	882	W
Morgan	--	--	1	757	--	--	--	--	757	--	757	W
Muskingum	1	38	8	3,010	2	91	194	465	2,480	--	3,139	7.73
Noble	--	--	2	677	--	--	--	438	239	--	677	W
Perry	1	2,141	5	535	--	--	1,445	1,231	--	--	2,677	7.04
Stark	--	--	7	331	--	--	--	331	--	--	331	6.90
Tuscarawas	--	--	19	1,469	3	67	37	1,499	--	--	1,536	6.59
Vinton	--	--	7	569	--	--	93	477	--	--	569	5.84
Wayne	--	--	1	47	--	--	--	47	--	--	47	W
Total [3]	28	16,225	176	28,527	31	1,031	28,871	11,555	5,343	14	45,783	7.40
Oklahoma:												
Craig	--	--	2	763	--	--	663	100	--	1	763	W
Haskell	--	--	4	341	--	--	339	2	--	(5)	341	13.93
Muskogee	--	--	1	54	--	--	54	--	--	--	54	W
Nowata	--	--	1	4	--	--	4	--	--	--	4	W
Rogers	--	--	3	1,020	--	--	1,001	20	--	--	1,020	6.67
Total [3]	--	--	11	2,183	--	--	2,060	122	--	1	2,183	7.69
Pennsylvania:												
Allegheny	7	3,631	13	618	1	11	3,125	1,135	--	(5)	4,260	11.98
Armstrong	14	4,138	71	2,586	14	77	1,482	2,398	2,886	35	6,801	7.86
Beaver	1	128	2	12	--	--	59	81	--	(5)	140	9.51
Blair	--	--	1	57	--	--	57	--	--	--	57	W
Butler	3	52	35	986	10	99	345	787	--	4	1,137	7.15
Cambria	18	6,054	31	1,650	1	14	5,686	1,829	187	14	7,717	14.04
Centre	1	469	15	499	--	--	680	276	--	12	968	10.07
Clarion	--	--	90	4,595	--	--	3,293	1,301	--	1	4,595	7.91
Clearfield	5	713	141	5,703	4	20	4,173	2,214	50	--	6,436	7.59
Clinton	--	--	7	453	--	--	220	233	--	--	453	7.30
Elk	--	--	17	650	3	23	212	461	--	--	673	6.96
Fayette	3	771	58	1,408	2	4	1,689	489	--	5	2,183	8.67
Greene	16	8,232	18	464	--	--	8,614	75	--	8	8,696	12.91
Indiana	24	7,328	54	1,745	4	44	3,902	1,085	4,122	8	9,117	9.66
Jefferson	4	71	47	1,454	4	19	1,300	240	--	3	1,543	8.02
Lawrence	--	--	16	507	5	24	--	531	--	--	531	6.52
Lycoming	--	--	3	132	--	--	--	132	--	--	132	4.35
Mercer	--	--	5	239	--	--	96	143	--	--	239	8.38
Somerset	17	1,329	73	3,203	5	24	3,080	1,476	--	(5)	4,556	8.66
Tioga	--	--	2	555	--	--	--	555	--	--	555	W
Venango	--	--	12	441	--	--	16	411	--	14	441	5.46
Washington	14	12,044	33	1,233	1	5	12,050	1,229	--	3	13,282	11.98
Westmoreland	7	1,248	31	638	1	3	1,143	743	--	3	1,889	10.34
Total [3]	134	46,207	775	29,829	55	366	51,223	17,824	7,246	110	76,408	10.30

See footnotes at end of table.

Table 18.—Production, shipments, and value at bituminous coal and lignite mines, in 1973, by State and county—Continued

(Thousand short tons)

State and county	Production						Shipments					Average value per ton [4]
	Underground		Strip		Auger							
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Rail or water [1]	Truck	Mine-mouth generating plants	All other [2]	Total [3]	
Tennessee:												
Anderson	18	767	10	930	4	177	325	1,549	--	--	1,874	$7.65
Bledsoe	--	--	1	20	--	--	--	20	--	--	20	W
Campbell	7	419	13	940	3	141	1,229	272	--	--	1,501	9.12
Claiborne	4	1,376	10	704	--	--	2,073	8	--	--	2,081	8.19
Cumberland	--	--	1	25	--	--	--	25	--	--	25	W
Fentress	1	14	2	48	--	--	42	20	--	--	62	7.11
Grundy	2	29	1	23	--	--	--	52	--	--	52	8.14
Marion	4	381	--	--	1	22	398	5	--	--	403	9.70
Morgan	--	--	7	450	1	8	--	458	--	--	458	7.13
Putnam	1	99	--	--	--	--	--	99	--	--	99	W
Roane	--	--	1	20	--	--	--	20	--	--	20	W
Scott	3	305	14	695	--	--	949	52	--	--	1,000	7.35
Sequatchie	6	245	2	161	--	--	392	14	--	--	406	7.93
Van Buren	--	--	2	218	--	--	194	24	--	--	218	W
Total [3]	46	3,636	64	4,236	9	348	5,601	2,618	--	--	8,219	8.13
Texas (lignite):												
Freestone	--	--	1	W	--	--	--	--	W	--	--	W
Harrison	--	--	1	W	--	--	--	W	--	--	--	W
Milan	--	--	1	W	--	--	--	--	W	--	--	W
Total [3]	--	--	3	6,944	--	--	--	W	W	--	6,944	W
Utah:												
Carbon	9	3,022	--	--	--	--	2,503	513	--	7	3,022	11.62
Emery	6	2,138	--	--	--	--	1,436	703	--	--	2,138	W
Sevier	1	339	--	--	--	--	63	276	--	--	339	W
Total [3]	16	5,500	--	--	--	--	4,001	1,492	--	7	5,500	11.19
Virginia:												
Buchanan	195	10,729	60	1,828	57	946	12,907	595	--	--	13,503	12.82
Dickenson	36	3,758	32	902	11	135	4,765	30	--	--	4,795	11.37
Lee	12	805	10	239	6	92	1,036	100	--	--	1,136	8.54
Russell	4	1,686	15	627	9	172	2,424	61	--	--	2,485	11.27
Scott	1	7	1	2	--	--	3	6	--	--	9	9.08
Tazewell	9	1,320	5	328	1	3	1,457	194	--	--	1,651	10.35
Wise	43	5,132	119	4,774	24	476	10,081	298	--	3	10,382	9.13
Total [3]	300	23,437	242	8,700	108	1,824	32,673	1,285	--	3	33,961	11.12
Washington:												
King	1	16	--	--	--	--	--	16	--	--	16	W
Lewis	--	--	2	3,254	--	--	--	8	3,246	--	3,254	W
Total	1	16	2	3,254	--	--	--	24	3,246	--	3,270	6.56

West Virginia:												
Barbour	8	1,326	34	3,116	7	132	4,072	494	--	7	4,574	8.91
Boone	46	8,901	22	1,992	11	310	10,782	408	--	13	11,203	10.57
Brooke	2	636	7	120	1	22	126	132	520	(5)	778	8.67
Clay	9	35	--	--	--	--	35	--	--	--	35	8.50
Fayette	21	2,580	20	1,798	7	118	4,475	19	--	2	4,496	11.24
Grant	3	1,410	7	201	--	--	1,452	159	--	--	1,611	7.84
Greenbrier	7	114	11	377	1	6	344	153	--	--	497	11.19
Harrison	4	3,206	13	729	2	63	2,524	29	1,444	--	3,997	8.09
Kanawha	36	6,597	25	1,034	23	541	8,064	105	--	2	8,171	11.46
Lewis	1	1	12	235	5	40	264	12	--	--	276	7.90
Logan	50	7,620	7	586	6	225	8,402	27	--	2	8,431	12.55
McDowell	89	12,020	17	640	4	64	12,545	96	--	83	12,724	16.71
Marion	7	6,199	1	20	--	--	6,094	20	--	105	6,220	9.62
Marshall	4	6,108	--	--	--	--	2,274	64	3,770	--	6,108	7.83
Mason	1	355	--	--	--	--	--	--	355	--	355	9.54
Mercer	4	1,100	--	--	4	38	1,136	2	--	--	1,138	15.97
Mineral	1	144	9	251	--	--	189	205	--	--	395	6.68
Mingo	31	2,776	7	323	5	187	3,258	28	--	(5)	3,286	10.98
Monongalia	16	10,572	9	888	2	31	11,209	178	98	6	11,492	8.26
Nicholas	38	4,779	23	1,208	7	61	5,980	69	--	--	6,049	12.99
Ohio	2	1,967	--	--	--	--	1,794	129	--	44	1,967	W
Preston	10	847	26	886	--	--	701	1,016	--	15	1,732	7.08
Raleigh	36	5,180	14	843	6	68	5,984	94	--	13	6,091	15.43
Randolph	7	158	13	726	2	6	863	27	--	--	889	8.33
Taylor	--	--	4	200	1	2	200	2	--	--	203	7.29
Tucker	--	--	2	180	--	--	180	--	--	--	180	W
Upshur	7	345	7	888	2	20	1,213	40	--	--	1,253	7.98
Wayne	2	582	--	--	--	--	578	5	--	--	582	W
Webster	8	123	3	64	1	108	273	23	--	--	296	9.17
Wyoming	72	9,834	11	399	9	185	10,163	238	--	17	10,418	15.09
Total [3]	522	95,516	304	17,704	106	2,228	105,174	3,776	6,188	311	115,448	11.61
Wyoming:												
Campbell	--	--	2	1,623	--	--	1,378	10	214	21	1,623	W
Carbon	1	315	4	6,530	--	--	6,842	3	--	--	6,845	4.21
Converse	--	--	2	2,899	--	--	--	--	2,897	1	2,899	W
Hot Springs	2	7	--	--	--	--	--	7	--	--	7	W
Lincoln	--	--	2	2,947	--	--	400	--	2,546	(5)	2,947	W
Sheridan	--	--	2	463	--	--	438	26	--	--	463	4.00
Sweetwater	2	103	--	--	--	--	42	(5)	--	61	108	W
Total [3]	5	425	12	14,461	--	--	9,100	45	5,658	84	14,886	4.09
Total United States [3]	1,737	299,353	2,309	276,645	698	15,739	465,762	57,268	64,424	4,284	591,738	8.53

W Withheld to avoid disclosing individual company data.

[1] Includes coal loaded at mine directly into railroad cars or river barges, hauled by trucks to railroad sidings, and hauled by trucks by slurry pipeline in Arizona.

[2] Includes coal used at mine for power and heat, made into beehive coke at mine, used by mine employees, used for all other purposes at mine and shipped by slurry pipeline from Arizona.

[3] Data may not add to totals shown because of independent rounding.

[4] Value received or charged for coal f.o.b. mine. Includes a value for coal not sold but used by producers, such as mine fuel and coal coked as estimated by producers at average prices that might have been received if such coal had been sold commercially.

[5] Less than 500 tons.

Table 19.—Number of mines, men working daily, days active, and output per man per day at bituminous coal and lignite mines in the United States, in 1973, by State and county

State and county	Number of mines			Average number of men working daily				Average number of days worked			Average tons per man per day			
	Under-ground	Strip	Auger	Under-ground	Strip	Auger	Total	Under-ground	Strip	Auger	Under-ground	Strip	Auger	Total
Alabama:														
Bibb	--	2	--	--	130	--	130	--	266	--	--	23.95	--	23.95
Blount	--	5	--	--	75	--	75	--	249	--	--	11.75	--	11.75
Cullman	--	9	--	--	139	--	139	--	221	--	--	24.96	--	24.96
Etowah	--	1	--	--	7	--	7	--	54	--	--	18.64	--	18.64
Fayette	1	--	--	105	--	--	105	79	--	--	2.55	--	--	2.55
Jackson	--	1	--	--	124	--	124	--	300	--	--	21.98	--	21.98
Jefferson	14	22	1	2,297	490	6	2,793	234	266	260	9.02	28.26	53.61	12.88
Marion	3	2	--	22	60	--	82	139	201	--	9.08	20.03	--	17.78
Shelby	--	1	--	--	18	--	18	--	180	--	--	32.79	--	32.79
Tuscaloosa	--	8	--	--	241	--	241	--	189	--	--	33.60	--	33.60
Walker	3	29	--	850	502	--	1,352	260	255	--	12.35	24.79	--	16.91
Winston	--	3	--	--	32	--	32	--	222	--	--	22.60	--	22.60
Total	21	83	1	3,274	1,818	6	5,098	235	246	260	9.91	25.76	53.61	15.79
Alaska	--	1	--	--	74	--	74	--	277	--	--	33.86	--	33.86
Arizona: Navajo	--	1	--	--	161	--	161	--	297	--	--	67.90	--	67.90
Arkansas:														
Franklin	--	2	--	--	29	--	29	--	188	--	--	13.24	--	13.24
Johnson	1	3	--	5	64	--	69	109	218	--	4.60	11.95	--	11.67
Logan	--	2	--	--	10	--	10	--	170	--	--	11.35	--	11.35
Sebastian	--	3	--	--	49	--	49	--	276	--	--	12.84	--	12.84
Total	1	10	--	5	152	--	157	109	228	--	4.60	12.47	--	12.35
Colorado:														
Delta	2	--	--	76	--	--	76	244	--	--	11.42	--	--	11.42
Fremont	4	2	1	21	18	9	48	231	244	98	16.11	29.29	43.62	24.13
Garfield	1	--	--	1	--	--	1	189	--	--	6.61	--	--	6.61
Gunnison	3	--	--	256	--	--	256	242	--	--	13.66	--	--	13.66
La Plata	1	--	--	8	--	--	8	268	--	--	4.31	--	--	4.31
Las Animas	1	--	--	418	--	--	418	261	--	--	5.72	--	--	5.72
Moffat	2	--	--	61	--	--	61	243	--	--	19.56	--	--	19.56
Montrose	--	1	--	--	16	--	16	--	297	--	--	22.47	--	22.47
Pitkin	4	1	--	238	28	--	266	260	23	--	12.56	5.68	--	12.49
Routt	1	4	--	5	124	--	129	231	314	--	8.75	66.64	--	64.86
Weld	2	--	--	139	--	--	139	234	--	--	15.68	--	--	15.68
Total	21	8	1	1,223	186	9	1,418	251	262	98	10.93	58.15	43.62	17.46
Illinois:														
Christian	1	--	--	768	--	--	768	241	--	--	22.41	--	--	22.41
Douglas	2	--	--	311	--	--	311	234	--	--	22.29	--	--	22.29
Franklin	3	--	--	1,258	--	--	1,258	251	--	--	20.52	--	--	20.52
Fulton	--	3	--	--	479	--	479	--	245	--	--	26.71	--	26.71
Gallatin	2	1	--	649	106	--	755	259	153	--	9.26	19.06	--	10.12
Jackson	--	2	--	--	20	--	20	--	103	--	--	37.56	--	37.56

Jefferson	3	1	--	1,490	43	--	1,533	260	232	--	17.10	66.57	--	18.34
Johnson	--	1	--	--	3	--	3	--	47	--	--	35.02	--	35.02
Kankakee	--	1	--	--	85	--	85	--	293	--	--	16.64	--	16.64
Knox	--	1	--	--	165	--	165	--	190	--	--	32.40	--	32.40
Macoupin	1	--	--	431	--	--	431	246	--	--	25.42	--	--	25.42
Mercer	1	1	--	11	10	--	21	85	15	--	13.15	37.51	--	16.52
Montgomery	1	--	--	360	--	--	360	235	--	--	22.31	--	--	22.31
Peoria	--	3	--	--	334	--	334	--	203	--	--	25.93	--	25.93
Perry	--	5	--	--	750	--	750	--	295	--	--	50.69	--	50.69
Randolph	2	2	--	455	270	--	725	242	269	--	18.28	39.00	--	26.51
St. Clair	1	2	--	595	416	--	1,011	261	264	--	15.16	39.12	--	25.09
Saline	2	4	--	345	181	--	526	260	244	--	15.50	24.85	--	18.58
Stark	--	1	--	--	84	--	84	--	202	--	--	22.35	--	22.35
Wabash	1	--	--	59	--	--	59	72	--	--	8.97	--	--	8.97
Williamson	3	4	--	497	325	--	822	247	232	--	14.24	23.86	--	17.90
Total	23	32	--	7,229	3,271	--	10,500	249	248	--	18.07	35.80	--	23.56
Indiana:														
Clay	--	6	--	--	168	--	168	--	275	--	--	27.99	--	27.99
Fountain	--	1	--	--	11	--	11	--	208	--	--	17.02	--	17.02
Gibson	1	1	--	202	5	--	207	168	82	--	18.11	37.93	--	18.35
Greene	--	5	--	--	237	--	237	--	215	--	--	20.81	--	20.81
Parke	--	1	--	--	2	--	2	--	240	--	--	3.94	--	3.94
Pike	1	8	--	18	599	--	617	204	284	--	25.05	33.49	--	33.31
Spencer	--	3	--	--	101	--	101	--	266	--	--	20.21	--	20.21
Sullivan	--	3	--	--	453	--	453	--	281	--	--	33.41	--	33.41
Vermillion	--	1	--	--	133	--	133	--	312	--	--	73.26	--	73.26
Vigo	1	--	--	20	--	--	20	224	--	--	18.37	--	--	18.37
Warrick	--	7	--	--	731	--	731	--	265	--	--	44.00	--	44.00
Total	3	36	--	240	2,440	--	2,680	175	270	--	18.74	37.08	--	35.98
Iowa:														
Lucas	1	--	--	25	--	--	25	300	--	--	14.20	--	--	14.20
Mahaska	--	4	--	--	34	--	34	--	200	--	--	19.78	--	19.78
Marion	--	4	--	--	27	--	27	--	121	--	--	19.67	--	19.67
Monroe	1	--	--	28	--	--	28	285	--	--	31.23	--	--	31.23
Wapello	--	2	--	--	14	--	14	--	198	--	--	16.58	--	16.58
Total	2	10	--	53	75	--	128	292	171	--	22.98	19.06	--	21.20
Kansas:														
Cherokee	--	2	--	--	118	--	118	--	295	--	--	21.03	--	21.03
Crawford	--	2	--	--	110	--	110	--	293	--	--	10.98	--	10.98
Total	--	4	--	--	228	--	228	--	294	--	--	16.20	--	16.20
Kentucky:														
Eastern:														
Bell	21	16	10	362	432	58	852	155	215	144	11.51	28.45	53.02	23.71
Boyd	--	4	2	--	55	7	62	--	97	90	--	28.56	26.23	28.31
Breathitt	--	36	31	--	431	130	561	--	248	248	--	42.87	54.90	46.66
Carter	--	4	--	--	45	--	45	--	76	--	--	20.83	--	20.83
Clay	5	6	5	107	63	25	195	135	100	169	10.01	27.82	49.23	21.15
Elliott	--	3	1	--	32	1	33	--	157	125	--	34.98	15.85	34.52
Floyd	103	23	28	1,471	300	72	1,843	174	109	121	9.35	37.26	90.64	14.81
Harlan	67	27	32	2,582	125	85	2,792	242	110	135	14.35	52.65	54.48	15.87
Jackson	--	1	--	--	3	--	3	--	44	--	--	18.70	--	18.70

Table 19.—Number of mines, men working daily, days active, and output per man per day at bituminous coal and lignite mines in the United States, in 1973, by State and county—Continued

State and county	Number of mines			Average number of men working daily				Average number of days worked			Average tons per man per day			
	Underground	Strip	Auger	Underground	Strip	Auger	Total	Underground	Strip	Auger	Underground	Strip	Auger	Total
Kentucky:														
Eastern—Continued														
Johnson	3	19	17	64	135	69	268	245	111	112	9.42	30.00	35.00	22.60
Knott	48	17	23	1,086	82	61	1,229	195	143	195	14.54	41.97	33.76	16.88
Knox	3	28	17	15	237	68	320	253	110	62	4.19	24.80	48.45	25.43
Laurel	--	13	9	--	112	25	137	--	70	68	--	29.31	45.09	32.10
Lawrence	--	5	3	--	84	10	94	--	95	178	--	87.87	53.31	32.48
Lee	1	--	--	16	--	--	16	234	--	--	5.21	--	--	5.21
Leslie	14	16	19	313	111	60	484	251	150	129	18.84	36.60	40.49	23.34
Letcher	59	23	28	1,540	332	113	1,985	215	159	149	9.46	19.00	38.03	11.92
McCreary	4	3	1	297	52	3	352	222	127	123	13.43	20.85	22.29	14.15
Magoffin	--	11	7	--	123	34	157	--	168	120	--	32.62	27.54	31.77
Martin	12	15	7	764	345	36	1,145	256	167	182	13.67	55.07	45.96	23.68
Morgan	--	2	1	--	19	2	21	--	233	200	--	28.75	15.41	27.65
Owsley	--	5	3	--	44	18	62	--	132	132	--	26.19	30.10	27.33
Perry	28	25	29	977	350	177	1,504	247	226	126	10.53	27.79	46.39	16.85
Pike	210	63	83	5,147	399	374	5,920	207	157	121	13.30	45.00	46.40	16.27
Pulaski	2	1	--	37	42	--	79	192	240	--	9.34	31.17	--	22.14
Rockcastle	--	1	1	--	4	3	7	--	77	75	--	20.74	14.17	17.97
Wayne	--	2	2	--	6	4	10	--	145	145	--	53.88	40.35	48.47
Whitley	4	30	20	90	190	43	323	250	150	124	8.63	21.68	41.05	18.30
Total	584	399	379	14,868	4,153	1,478	20,499	215	164	139	12.70	34.75	47.46	18.13
Kentucky:														
Western:														
Butler	1	6	--	19	31	--	50	80	88	--	3.85	28.44	--	20.65
Christian	--	1	--	--	20	--	20	--	240	--	--	35.66	--	35.66
Daviess	--	1	--	--	94	--	94	--	253	--	--	41.10	--	41.10
Edmonson	--	1	--	--	20	--	20	--	240	--	--	19.97	--	19.97
Henderson	1	--	--	95	--	--	95	284	--	--	22.25	--	--	22.25
Hopkins	9	13	--	1,351	389	--	1,740	243	210	--	17.60	52.20	--	24.50
McLean	--	5	--	--	151	--	151	--	213	--	--	40.78	--	40.78
Muhlenberg	5	15	--	1,044	1,539	--	2,583	263	267	--	19.02	46.50	--	35.49
Ohio	3	12	--	420	502	--	922	269	267	--	19.43	39.59	--	30.37
Union	6	--	--	1,612	--	--	1,612	263	--	--	16.73	--	--	16.73
Webster	1	1	--	175	14	--	189	293	99	--	28.32	22.28	--	28.16
Total	26	55	—	4,716	2,760	--	7,476	259	252	--	18.32	45.01	--	28.02
Total Kentucky	610	454	379	19,584	6,913	1,478	27,975	225	199	139	14.25	39.94	47.46	21.29
Maryland:														
Allegany	--	16	3	--	95	6	101	--	203	95	--	26.00	18.20	25.78
Garrett	2	30	5	15	197	9	221	199	195	253	22.84	29.73	30.24	29.30
Total	2	46	8	15	292	15	322	194	198	190	22.84	28.48	27.83	28.20

Missouri:														
Barton	--	1	--	--	50	--	50	--	300	--	--	39.98	--	39.98
Bates	--	1	--	--	74	--	74	--	344	--	--	38.07	--	38.07
Henry	--	2	--	--	215	--	215	--	282	--	--	28.47	--	28.47
Howard	--	1	--	--	5	--	5	--	219	--	--	17.43	--	17.43
Macon	--	1	--	--	157	--	157	--	199	--	--	23.00	--	23.00
Putnam	--	1	--	--	29	--	29	--	285	--	--	8.72	--	8.72
Randolph	--	1	--	--	43	--	43	--	237	--	--	49.98	--	49.98
Vernon	--	2	--	--	6	--	6	--	215	--	--	32.27	--	32.27
Total	--	10	--	--	579	--	579	--	265	--	--	30.39	--	30.39
Montana (bituminous):														
Big Horn	--	1	--	--	74	--	74	--	365	--	--	153.99	--	153.99
Musselshell	1	3	--	5	9	--	14	52	56	--	4.06	49.85	--	34.18
Rosebud	--	2	--	--	182	--	182	--	280	--	--	122.20	--	122.20
Total	1	6	--	5	265	--	270	52	296	--	4.06	132.68	--	132.26
Montana (lignite):														
Powder River	--	1	--	--	1	--	1	--	155	--	--	9.32	--	9.32
Richland	--	1	--	--	21	--	21	--	262	--	--	56.85	--	56.85
Total	--	2	--	--	22	--	22	--	257	--	--	55.55	--	55.55
Total Montana	1	8	--	5	287	--	292	52	293	--	4.06	127.50	--	127.11
New Mexico:														
Colfax	1	1	--	239	21	--	260	239	248	--	12.82	36.87	--	14.83
McKinley	--	2	--	--	30	--	30	--	210	--	--	74.25	--	74.25
San Juan	--	2	--	--	429	--	429	--	273	--	--	65.60	--	65.60
Total	1	5	--	239	480	--	719	239	268	--	12.82	64.86	--	48.84
North Dakota (lignite):														
Adams	--	1	--	--	1	--	1	--	164	--	--	7.50	--	7.50
Bowman	--	1	--	--	19	--	19	--	253	--	--	38.49	--	38.49
Burke	--	1	--	--	34	--	34	--	271	--	--	52.37	--	52.37
Grant	--	1	--	--	2	--	2	--	150	--	--	16.72	--	16.72
Mercer	--	3	--	--	139	--	139	--	256	--	--	115.08	--	115.08
Oliver	--	1	--	--	35	--	35	--	263	--	--	169.76	--	169.76
Stark	--	2	--	--	12	--	12	--	202	--	--	44.43	--	44.43
Ward	--	1	--	--	21	--	21	--	261	--	--	82.36	--	82.36
Williams	--	1	--	--	2	--	2	--	125	--	--	31.32	--	31.32
Total	--	12	--	--	265	--	265	--	255	--	--	102.36	--	102.36
Ohio:														
Belmont	7	28	5	2,427	836	36	3,299	221	279	75	13.30	38.18	112.53	21.16
Carroll	--	4	1	--	39	3	42	--	290	183	--	21.68	35.03	22.30
Columbiana	3	17	5	14	158	18	190	176	244	101	13.24	19.37	39.28	19.85
Coshocton	1	9	1	228	230	8	466	265	237	230	12.82	31.07	39.13	21.74
Gallia	--	2	1	--	13	2	15	--	89	50	--	15.51	60.00	19.03
Guernsey	--	3	--	--	56	--	56	--	165	--	--	39.83	--	39.83
Harrison	4	11	1	1,711	310	8	2,029	231	198	233	9.47	56.37	60.40	15.95
Hocking	--	6	--	--	42	--	42	--	181	--	--	32.44	--	32.44
Holmes	--	7	1	--	54	2	56	--	234	132	--	49.04	51.82	49.10
Jackson	5	5	1	58	84	2	144	153	263	66	27.10	33.73	78.74	32.03
Jefferson	3	27	10	337	529	31	897	224	190	77	11.67	36.43	113.65	26.99
Lawrence	--	1	--	--	10	--	10	--	245	--	--	8.97	--	8.97

Table 19.—Number of mines, men working daily, days active, and output per man per day at bituminous coal and lignite mines in the United States, in 1973, by State and county—Continued

State and county	Number of mines			Average number of men working daily				Average number of days worked			Average tons per man per day			
	Underground	Strip	Auger	Underground	Strip	Auger	Total	Underground	Strip	Auger	Underground	Strip	Auger	Total
Ohio—Continued														
Mahoning	--	6	--	--	62	--	62	--	220	--	--	29.20	--	29.20
Meigs	2	--	--	204	--	--	204	196	--	--	8.95	--	--	8.95
Monroe	1	--	--	482	--	--	482	212	--	--	8.63	--	--	8.63
Morgan	--	1	--	--	56	--	56	--	239	--	--	56.60	--	56.60
Muskingum	1	8	2	13	414	15	442	167	100	150	17.50	72.70	40.56	68.51
Noble	--	2	--	--	81	--	81	--	131	--	--	63.85	--	63.85
Perry	1	5	--	508	80	--	588	279	243	--	15.11	27.66	--	16.62
Stark	--	7	--	--	117	--	117	--	158	--	--	17.90	--	17.90
Tuscarawas	--	19	3	--	308	6	314	--	248	192	--	19.21	58.70	19.79
Vinton	--	7	--	--	104	--	104	--	237	--	--	23.09	--	23.09
Wayne	--	1	--	--	4	--	4	--	216	--	--	57.98	--	57.98
Total	28	176	31	5,982	3,587	131	9,700	228	216	114	11.89	36.88	69.15	21.26
Oklahoma:														
Craig	--	2	--	--	97	--	97	--	280	--	--	28.09	--	28.09
Haskell	--	4	--	--	107	--	107	--	293	--	--	10.89	--	10.89
Muskogee	--	1	--	--	26	--	26	--	251	--	--	8.28	--	8.28
Nowata	--	1	--	--	14	--	14	--	13	--	--	19.02	--	19.02
Rogers	--	3	--	--	136	--	136	--	330	--	--	22.74	--	22.74
Total	--	11	--	--	380	--	380	--	290	--	--	19.82	--	19.82
Pennsylvania:														
Allegheny	7	13	1	1,389	103	2	1,494	239	243	156	10.94	24.70	34.78	11.93
Armstrong	14	71	14	1,305	441	45	1,791	237	166	63	13.38	35.33	27.31	17.65
Beaver	1	2	--	48	29	--	77	240	21	--	11.11	19.70	--	11.54
Blair	--	1	--	--	10	--	10	--	245	--	--	23.42	--	23.42
Butler	3	35	10	96	283	32	411	52	205	74	10.42	17.00	41.40	17.39
Cambria	18	31	1	3,527	354	5	3,886	255	220	79	6.73	21.20	34.77	7.89
Centre	1	15	--	191	97	--	288	227	206	--	10.81	25.00	--	15.29
Clarion	--	90	--	--	748	--	748	--	211	--	--	29.10	--	29.10
Clearfield	5	141	4	259	1,092	12	1,363	237	265	76	11.61	19.70	22.42	18.30
Clinton	--	7	--	--	87	--	87	--	316	--	--	16.50	--	16.50
Elk	--	17	3	--	103	12	115	--	234	52	--	27.04	36.06	27.27
Fayette	3	58	2	604	175	5	784	248	230	23	5.15	34.98	37.66	11.49
Greene	16	18	--	3,468	62	--	3,530	245	120	--	9.69	62.87	--	10.15
Indiana	24	54	4	3,156	406	20	3,582	235	226	92	9.88	19.00	24.25	10.91
Jefferson	4	47	4	30	294	9	333	277	228	63	8.50	21.69	34.15	20.34
Lawrence	--	16	5	--	115	7	122	--	273	81	--	16.21	43.14	16.67
Lycoming	--	3	--	--	18	--	18	--	265	--	--	27.74	--	27.74
Mercer	--	5	--	--	35	--	35	--	263	--	--	25.92	--	25.92
Somerset	17	73	5	583	737	7	1,327	230	244	80	9.91	17.81	42.07	14.48
Tioga	--	2	--	--	97	--	97	--	268	--	--	21.33	--	21.33
Venango	--	12	--	--	69	--	69	--	220	--	--	29.02	--	29.02
Washington	14	33	1	4,093	282	3	4,378	274	137	63	10.74	32.00	26.28	11.45

Westmoreland	7	31	1	691	135	2	828	192	173	78	9.41	27.24	21.19	12.09
Total	134	775	55	19,440	5,772	161	25,373	247	224	71	9.63	23.11	32.15	12.52
Tennessee:														
Anderson	18	10	4	210	95	18	323	182	232	206	20.02	42.25	47.14	29.25
Bledsoe	--	1	--	--	5	--	5	--	206	--	--	19.44	--	19.44
Campbell	7	13	3	131	172	13	316	260	198	205	12.30	27.63	52.66	21.19
Clairborne	4	10	--	405	110	--	515	234	208	--	14.52	30.79	--	17.68
Cumberland	--	1	--	--	5	--	5	--	185	--	--	27.03	--	27.03
Fentress	1	2	--	13	8	--	21	155	251	--	6.95	24.02	--	15.48
Grundy	2	1	--	13	6	--	19	162	105	--	13.73	36.27	--	18.92
Marion	4	--	1	113	--	11	124	212	--	71	15.94	--	27.99	16.32
Morgan	--	7	1	--	55	2	57	--	206	99	--	39.46	40.40	39.48
Putnam	1	--	--	33	--	--	33	199	--	--	15.05	--	--	15.05
Roane	--	1	--	--	7	--	7	--	116	--	--	24.60	--	24.60
Scott	3	14	--	138	185	--	323	153	165	--	14.48	22.83	--	19.42
Sequatchie	6	2	--	114	20	--	134	250	258	--	8.59	30.58	--	12.02
Van Buren	--	2	--	--	52	--	52	--	188	--	--	22.27	--	22.27
Total	46	64	9	1,170	720	44	1,934	215	196	168	14.46	29.99	46.95	20.54
Texas (lignite):														
Freestone	--	1	--	--	92	--	92	--	295	--	--	173.20	--	173.20
Harrison	--	1	--	--	18	--	18	--	365	--	--	37.15	--	37.15
Milan	--	1	--	--	105	--	105	--	335	--	--	56.77	--	56.77
Total	--	3	--	--	215	--	215	--	321	--	--	100.75	--	100.75
Utah:														
Carbon	9	--	--	1,023	--	--	1,023	235	--	--	12.57	--	--	12.57
Emery	6	--	--	550	--	--	550	244	--	--	15.93	--	--	15.93
Sevier	1	--	--	30	--	--	30	273	--	--	41.45	--	--	41.45
Total	16	--	--	1,603	--	--	1,603	239	--	--	14.36	--	--	14.36
Virginia:														
Buchanan	195	60	57	5,254	354	123	5,731	217	208	149	9.41	24.82	51.67	10.96
Dickenson	36	32	11	1,674	138	38	1,850	224	218	104	10.02	29.99	33.80	11.72
Lee	12	10	6	277	50	22	349	212	193	157	13.70	24.80	26.62	15.81
Russell	4	15	9	761	99	21	881	237	211	126	9.35	30.00	63.96	12.19
Scott	1	1	--	8	2	--	10	138	30	--	6.14	30.00	--	7.37
Tazewell	9	5	1	653	45	2	700	218	194	52	9.27	37.57	27.73	10.92
Wise	43	119	24	2,073	575	57	2,705	225	242	169	11.00	34.27	49.32	16.87
Total	300	242	108	10,700	1,263	263	12,226	221	224	145	9.91	30.81	47.75	12.65
Washington:														
King	1	--	--	16	--	--	16	194	--	--	5.26	--	--	5.26
Lewis	--	2	--	--	302	--	302	--	268	--	--	40.19	--	40.19
Total	1	2	--	16	302	--	318	194	268	--	5.26	40.19	--	38.90
West Virginia:														
Barbour	8	34	7	471	454	42	967	243	198	97	11.59	34.66	32.30	21.95
Boone	46	22	11	3,305	451	94	3,850	259	125	73	10.40	35.35	45.00	12.19
Brooke	2	7	1	221	34	3	258	236	140	133	12.19	25.00	54.38	13.56
Clay	9	--	--	55	--	--	55	45	--	--	14.25	--	--	14.25
Fayette	21	20	7	1,295	276	30	1,601	235	163	100	8.48	40.00	39.33	12.77
Grant	3	7	--	431	111	--	542	250	256	--	13.08	7.08	--	11.83
Greenbrier	7	11	1	94	80	5	179	178	157	55	6.83	29.90	23.08	16.79

Table 19.—Number of mines, men working daily, days active, and output per man per day at bituminous coal and lignite mines in the United States, in 1973, by State and county—Continued

State and county	Number of mines			Average number of men working daily				Average number of days worked			Average tons per man per day			
	Underground	Strip	Auger	Underground	Strip	Auger	Total	Underground	Strip	Auger	Underground	Strip	Auger	Total
West Virginia—Continued														
Harrison	4	13	2	860	130	8	998	224	160	146	16.64	35.00	53.68	18.62
Kanawha	36	25	23	3,029	239	185	3,453	218	120	99	9.99	36.03	29.52	11.55
Lewis	1	12	5	3	94	31	128	43	87	32	9.97	28.68	40.51	29.67
Logan	50	7	6	3,552	141	75	3,768	218	135	98	9.84	30.89	30.65	10.53
McDowell	89	17	4	5,949	198	19	6,166	226	122	102	8.94	26.49	32.65	9.28
Marion	7	1	--	2,206	6	--	2,212	230	73	--	12.22	46.39	--	12.25
Marshall	4	--	--	1,682	--	--	1,682	231	--	--	15.72	--	--	15.72
Mason	1	--	--	159	--	--	159	223	--	--	10.01	--	--	10.01
Mercer	4	--	4	531	--	18	549	239	--	87	8.67	--	24.29	8.86
Mineral	1	9	--	34	114	--	148	260	281	--	16.29	7.82	--	9.65
Mingo	31	7	5	1,163	120	33	1,316	218	96	86	10.95	28.09	65.91	12.27
Monongolia	16	9	2	2,780	99	4	2,883	224	189	136	16.98	47.28	59.50	17.90
Nicholas	38	23	7	2,180	282	69	2,531	221	153	83	9.92	28.01	10.67	11.40
Ohio	2	--	--	887	--	--	887	232	--	--	9.56	--	--	9.56
Preston	10	26	--	227	178	--	405	228	207	--	16.36	24.10	--	19.57
Raleigh	36	14	6	3,218	272	22	3,512	214	214	85	7.52	14.51	37.31	8.14
Randolph	7	13	2	155	255	5	415	111	128	69	9.17	22.24	17.71	17.73
Taylor	--	4	1	--	40	16	56	--	171	40	--	29.26	3.71	27.08
Tucker	--	2	--	--	21	--	21	--	261	--	--	32.81	--	32.81
Upshur	7	7	2	162	138	5	305	183	152	82	11.62	42.39	49.47	24.56
Wayne	2	--	--	193	--	--	193	251	--	--	12.02	--	--	12.02
Webster	8	3	1	96	31	14	141	101	71	202	12.72	29.02	38.25	21.08
Wyoming	72	11	9	5,199	136	50	5,385	224	170	73	8.44	17.28	50.39	8.74
Total	522	304	106	40,137	3,900	728	44,765	226	162	89	10.53	28.11	34.39	11.83
Wyoming:														
Campbell	--	2	--	--	53	--	53	--	288	--	--	106.45	--	106.45
Carbon	1	4	--	104	354	--	458	233	309	--	13.02	59.74	--	51.27
Converse	--	2	--	--	97	--	97	--	248	--	--	120.49	--	120.49
Hot Springs	2	--	--	7	--	--	7	125	--	--	7.45	--	--	7.45
Lincoln	--	2	--	--	302	--	302	--	228	--	--	42.87	--	42.87
Sheridan	--	2	--	--	37	--	37	--	222	--	--	56.33	--	56.33
Sweetwater	2	--	--	57	--	--	57	271	--	--	6.69	--	--	6.69
Total	5	12	--	168	843	--	1,011	241	268	--	10.49	64.11	--	55.94
Total United States	1,737	2,309	698	111,083	34,203	2,835	148,121	231	223	122	11.66	36.30	45.33	17.58

Table 20.—Underground mine data for bituminous coal, in 1973, by State

(Thousand short tons)

State	Number of mines	Production	Cut by hand and shot from solid	Cut by machines: Quantity	Cut by machines: Number of coal cutting machines	Cut by machines: Average output per machine	Mined by continuous-mining machines	Mined by longwall machines	Number of mines using power drills	Face or coal drills, Handheld and post mounted: Number	Face or coal drills, Handheld and post mounted: Quantity	Face or coal drills, Mobile: Number	Face or coal drills, Mobile: Quantity	Roof or rock drills, Roof bolting: Rotary	Roof or rock drills, Roof bolting: Percussion	Roof or rock drills, Roof bolting: Rotary-percussion	Roof or rock drills, Other uses: Rotary	Roof or rock drills, Other uses: Percussion	Roof or rock drills, Other uses: Rotary-percussion
Alabama	21	7,618	13	6,758	63	107	847	--	16	12	818	52	5,940	59	4	8	5	10	--
Arkansas	1	3	--	3	1	3	--	--	1	1	3	--	--	--	--	--	--	--	--
Colorado	21	3,361	1	66	8	8	2,982	312	3	10	66	--	--	40	2	--	--	--	--
Illinois	23	32,570	--	5,716	28	204	26,833	21	20	6	1,825	22	3,891	160	--	--	6	2	--
Indiana	3	789	--	174	2	22	614	--	3	--	--	2	174	6	--	--	--	2	--
Iowa	2	356	--	356	3	155	--	--	2	--	--	3	356	3	--	--	--	--	--
Kentucky:																			
Eastern	584	40,553	3,296	23,238	401	58	13,831	187	470	461	11,748	112	11,431	176	23	43	3	--	13
Western	26	22,342	--	22,342	102	219	--	--	26	1	6	99	22,064	148	--	--	--	--	--
Total [1]	610	62,895	3,296	45,580	503	91	13,831	187	496	462	11,754	211	33,496	324	23	43	3	--	13
Maryland	2	66	--	--	--	--	66	--	--	--	--	--	--	--	--	--	--	--	--
Montana (bituminous)	1	1	--	1	1	1	--	--	1	1	1	--	--	--	--	--	--	--	--
New Mexico	1	733	--	--	--	--	611	122	1	--	--	--	--	6	--	--	--	--	--
Ohio	28	16,225	--	5,292	52	102	10,933	--	22	8	647	39	4,646	203	--	2	--	--	--
Pennsylvania	134	46,207	4	1,843	56	33	41,611	2,749	92	34	415	21	1,422	239	169	129	--	12	2
Tennessee	46	3,636	5	2,265	61	37	1,366	--	45	59	1,249	6	1,020	25	1	1	--	--	--
Utah	16	5,500	--	469	4	117	4,217	814	14	--	--	4	469	13	16	7	--	--	2
Virginia	300	23,437	631	9,756	283	34	11,317	1,733	246	254	5,509	70	4,814	256	100	1	3	--	--
Washington	1	16	16	--	--	--	--	--	1	6	16	--	--	--	1	--	--	--	--
West Virginia	522	95,516	321	28,635	462	--	63,057	3,503	398	225	9,453	272	20,002	717	103	98	2	5	9
Wyoming	5	425	--	110	8	14	315	--	5	4	7	4	103	8	--	1	--	--	--
Grand total [1]	1,737	299,353	4,288	107,024	1,535	70	178,600	9,442	1,366	1,082	31,763	706	76,333	2,059	419	290	19	31	26

[1] Data may not add to totals shown because of independent rounding.

Table 21.—Haulage units in use in bituminous coal underground mines in the United States, in 1973, by State

State	Railroad: Locomotives: Trolley	Railroad: Locomotives: Battery	Railroad: Mines cars	Rubber-tired vehicles: Tractors	Rubber-tired vehicles: Trailers	Rubber-tired vehicles: Shuttle cars: Cable reel	Rubber-tired vehicles: Shuttle cars: Battery	Rubber-tired vehicles: Shuttle buggies	Gathering and haulage conveyors: Units	Gathering and haulage conveyors: Miles
Alabama	124	--	1,759	46	92	160	2	--	95	36.4
Arkansas	--	1	5	--	--	--	--	--	4	.4
Colorado	43	6	671	20	--	98	1	2	48	12.0
Illinois	70	37	98	120	137	388	22	1	293	153.0
Indiana	2	--	34	--	--	15	--	--	14	4.0
Iowa	6	--	48	--	--	6	--	--	--	--
Kentucky:										
Eastern	162	90	3,109	353	381	551	294	106	417	160.3
Western	30	47	116	95	54	237	35	--	194	81.9
Total	192	137	3,225	448	435	788	329	106	611	242.2
Maryland	--	--	--	--	--	--	2	--	1	.5
Montana (bituminous)	1	--	12	--	--	--	--	--	--	--
New Mexico	--	--	--	--	--	10	--	--	12	6.8
Ohio	115	18	2,301	98	83	215	43	--	145	54.0
Pennsylvania	1,015	29	11,876	346	693	1,103	23	6	717	279.6
Tennessee	25	10	184	74	102	42	18	4	46	15.6
Utah	56	1	1,450	26	45	92	3	--	66	18.8
Virginia	172	52	2,259	399	392	522	8	42	465	181.7
Washington	2	--	20	--	--	--	--	--	--	--
West Virginia	1,113	48	22,828	398	411	2,054	215	167	1,376	513.4
Wyoming	1	--	20	5	6	14	--	1	9	2.9
Grand total	2,937	339	46,790	1,980	2,396	5,507	666	329	3,902	1,521.3

Table 22.—Number and production of underground bituminous coal mines using gathering and haulage conveyors, and number and length of units in use, by State[1]

State	Number of mines		Production (thousand short tons)		Number of units in use		Average length (feet)		Total length (miles)	
	1972	1973	1972	1973	1972	1973	1972	1973	1972	1973
Alabama	8	7	6,016	6,266	82	95	1,925	2,023	29.9	36.4
Arkansas	1	1	8	3	4	4	500	500	.4	.4
Colorado	13	8	3,070	1,822	46	48	1,467	1,318	12.8	12.0
Illinois	22	21	31,593	30,259	286	293	2,723	2,758	r 147.5	153.0
Indiana	2	1	1,256	614	34	14	1,794	1,500	11.6	4.0
Kentucky:										
Eastern	94	116	18,781	24,606	349	417	2,216	2,030	146.5	160.3
Western	22	24	18,091	22,239	182	194	2,221	2,230	76.6	81.9
Total	116	140	36,872	46,845	531	611	2,218	2,094	223.1	242.2
Maryland	1	1	28	5	3	1	800	2,500	.5	.5
New Mexico	1	1	1,014	733	12	12	3,000	3,000	6.8	6.8
Ohio	27	19	16,155	13,894	171	145	2,005	1,967	64.9	54.0
Oklahoma	2	--	88	--	8	--	1,750	--	2.7	--
Pennsylvania	96	81	32,201	28,519	634	717	2,010	2,059	241.4	279.6
Tennessee	10	10	1,989	2,173	39	46	1,892	1,796	14.0	15.6
Utah	14	12	4,248	1,940	71	66	1,276	1,507	17.2	18.8
Virginia	71	90	17,111	16,754	421	465	2,136	2,063	170.3	181.7
West Virginia	285	292	87,667	83,800	1,426	1,376	2,219	1,970	r 599.3	513.4
Wyoming	1	3	3	415	8	9	1,813	1,689	2.7	2.9
Grand total[2]	670	687	239,319	234,042	3,776	3,902	2,160	2,059	r 1,545.1	1,521.3

r Revised.
[1] Includes all mines using belt conveyors, 500 feet long or more for transporting coal underground. Excludes mainslope conveyors.
[2] Data may not add to totals shown because of independent rounding.

Table 23.—Number and production of bituminous coal and lignite strip mines and units of stripping and loading equipment in 1972, by State

State	Number of strip mines	Production (thousand short tons)	Number of power shovels and dragline excavators											Number of carry-all scrapers	Number of bull-dozers	Front-end loaders	Wheel excavators	Power brooms	Motor graders	Coal drills
			By type of power				By capacity of dipper or bucket, cubic yards				By type of machine		Total							
			Electric	Diesel electric	Diesel	Gasoline	Less than 6	6–15	16–50	More than 50	Power shovels	Dragline excavators								
Alabama	83	11,529	14	13	86	1	62	27	22	3	70	44	114	5	192	161	--	3	20	6
Alaska	1	694	--	--	--	--	--	--	--	--	--	--	--	2	5	4	--	--	2	1
Arizona	1	3,247	3	1	--	--	--	--	3	1	2	2	4	--	5	2	--	--	1	1
Arkansas	10	432	1	3	4	--	1	7	--	--	1	7	8	--	17	10	--	2	3	--
Colorado	8	2,834	4	2	3	--	3	5	1	--	3	6	9	2	18	15	--	--	3	8
Illinois	32	29,002	71	13	25	1	34	33	21	22	58	52	110	16	172	59	11	2	35	24
Indiana	36	24,465	60	3	50	--	53	34	14	12	59	54	113	7	172	45	--	--	22	8
Iowa	10	245	--	--	20	--	17	3	--	--	7	13	20	4	15	9	--	--	3	11
Kansas	4	1,086	6	--	2	--	4	2	1	1	3	5	8	--	16	5	--	--	3	--
Kentucky:																				
Eastern	399	23,671	1	2	518	44	535	29	1	--	558	7	565	11	411	318	--	13	81	11
Western	55	31,337	58	9	86	--	89	40	16	8	112	41	153	4	241	91	--	1	33	8
Total	454	55,008	59	11	604	44	624	69	17	8	670	48	718	15	652	409	--	14	114	19
Maryland	46	1,643	--	--	66	--	58	8	--	--	44	22	66	--	65	51	--	--	6	2
Missouri	10	4,658	13	1	13	--	8	8	9	2	18	9	27	2	47	21	--	1	7	--
Montana:																				
Bituminous	6	10,410	7	--	--	--	--	3	4	--	4	3	7	5	14	9	--	--	4	6
Lignite	2	314	1	--	2	--	2	1	--	--	2	1	3	1	3	3	--	1	1	1
Total	8	10,724	8	--	2	--	2	4	4	--	6	4	10	6	17	12	--	1	5	7
New Mexico	5	8,336	5	1	3	--	1	3	5	--	4	5	9	2	16	10	--	--	8	5
North Dakota (lignite)	12	6,906	16	1	7	3	14	8	5	--	17	10	27	11	29	13	--	2	13	8
Ohio	176	28,527	37	20	267	5	229	81	13	6	222	107	329	114	576	301	--	19	81	4
Oklahoma	11	2,183	7	2	9	--	10	3	2	3	8	10	18	6	32	30	--	3	9	3
Pennsylvania	775	29,829	18	45	702	20	604	174	7	--	470	315	785	90	1,009	668	--	1	62	11
Tennessee	64	4,236	--	2	77	--	70	9	--	--	74	5	79	7	135	129	--	12	25	9
Texas (lignite)	3	6,944	8	--	3	--	2	3	4	2	6	5	11	2	12	3	--	--	6	--
Virginia	242	8,700	--	2	227	9	215	22	1	--	223	15	238	36	306	201	--	15	46	21
Washington	2	3,254	5	--	2	--	2	1	2	2	4	3	7	11	20	3	--	--	3	--
West Virginia	304	17,704	--	2	284	8	264	30	--	--	273	21	294	25	504	338	--	16	84	25
Wyoming	12	14,461	16	--	10	1	10	11	4	2	17	10	27	27	38	21	--	1	19	9
Grand total[1]	2,309	276,645	351	122	2,466	92	2,287	545	135	64	2,259	772	3,031	390	4,070	2,520	11	92	580	182

[1] Data may not add to totals shown because of independent rounding.

Table 24.—Equipment used at bituminous coal and lignite auger mines in the United States in 1973, by number of units

State	Augers	Power shovels	Power drills	Bull-dozers	Front-end loaders	Power brooms	Motor graders
Alabama	1	--	--	2	--	--	--
Colorado	1	--	--	--	--	--	--
Kentucky:							
Eastern	386	16	8	222	46	1	9
Western	--	--	--	--	--	--	--
Total	386	16	8	222	46	1	9
Maryland	7	--	--	2	3	--	--
Ohio	31	--	--	21	14	--	1
Pennsylvania	47	--	--	16	6	--	--
Tennessee	11	--	--	12	5	--	1
Virginia	117	--	18	101	50	2	7
West Virginia	93	1	4	53	14	--	3
Grand total	694	17	30	429	138	3	21

Table 25.—Bituminous coal mechanically loaded underground in the United States, by type of loading equipment

(Thousand short tons)

Type of loading equipment	1972	1973
Mobile loading machines:		
Directly into mine cars or onto conveyors	15,483	13,537
Into shuttle cars	99,508	95,804
Continuous-mining machines:		
Onto conveyors	11,673	10,178
Into shuttle or mine cars	132,792	140,207
Onto bottom	33,911	28,215
Longwall machines	7,763	9,442
Total mechanically loaded [1]	301,129	297,384

[1] Data may not add to totals shown because of independent rounding.

Table 26.—Comparative changes in underground mechanical loading of bituminous coal by principal types of loading devices in the United States, by State

(Thousand short tons)

State	Mobile loading machines		Continuous-mining machines		Longwall machines		Total mechanically loaded [1]	
	1972	1973	1972	1973	1972	1973	1972	1973
Alabama	6,636	6,729	891	847	--	--	7,527	7,576
Colorado	147	54	2,598	2,982	308	312	3,053	3,347
Illinois	7,295	5,716	24,411	26,833	15	21	31,721	32,570
Indiana	373	174	1,073	614	--	--	1,446	789
Iowa	352	356	--	--	--	--	352	356
Kentucky:								
Eastern	23,631	25,522	12,699	13,831	--	187	36,329	39,540
Western	18,465	22,342	83	--	--	--	18,547	22,342
Total	42,095	47,864	12,781	13,831	--	187	54,877	61,883
Maryland	7	--	128	66	--	--	135	66
Montana	7	--	--	--	--	--	7	--
New Mexico	--	--	1,014	611	--	122	1,014	733
Ohio	5,692	5,292	10,568	10,933	--	--	16,260	16,225
Oklahoma	--	--	88	--	--	--	88	--
Pennsylvania	3,647	1,743	42,997	41,611	2,354	2,749	48,998	46,103
Tennessee	4,376	2,230	1,311	1,366	--	--	5,687	3,596
Utah	442	469	3,604	4,217	723	814	4,770	5,500
Virginia	11,480	10,116	11,269	11,317	1,217	1,733	23,967	23,167
Washington	29	16	--	--	--	--	29	16
West Virginia	32,309	28,474	65,306	63,057	3,146	3,503	100,762	95,034
Wyoming	103	107	335	315	--	--	438	422
Grand total [1]	114,990	109,342	178,375	178,600	7,763	9,442	301,129	297,384

[1] Data may not add to totals shown because of independent rounding.

Table 27.—Number of bituminous coal and lignite underground mines using mechanical loading devices and number of units in use in the United States, by State

State	Number of mines								Number of loading devices					
	Using mobile loading machines		Using continuous-mining machines only		Using more than one type of loading device		Total		Mobile loading machines		Continuous-mining machines		Longwall machines	
	1972	1973	1972	1973	1972	1973	1972	1973	1972	1973	1972	1973	1972	1973
Alabama	9	9	--	--	4	5	13	14	68	72	7	9	--	--
Colorado	7	3	12	14	4	2	23	19	r 28	14	39	41	1	1
Illinois	10	6	12	12	4	5	26	23	42	29	139	156	1	1
Indiana	2	2	1	1	1	--	4	3	6	2	7	5	--	--
Iowa	2	2	--	--	--	--	2	2	5	4	--	--	--	--
Kentucky:														
Eastern	377	368	54	54	10	8	441	430	r 536	r 551	139	152	--	1
Western	25	26	1	--	1	--	27	26	130	139	3	--	--	--
Total	402	394	55	54	11	8	468	456	r 666	r 690	142	152	--	1
Maryland	1	--	2	2	--	--	3	2	2	--	2	2	--	--
Montana	1	--	--	--	--	--	1	--	2	--	--	--	--	--
New Mexico	--	--	--	--	1	1	1	1	6	5	6	5	--	1
Ohio	13	7	15	16	5	6	33	29	68	57	112	103	--	--
Oklahoma	--	--	2	--	--	--	2	--	--	--	6	--	--	--
Pennsylvania	19	15	90	86	18	15	127	116	r 109	r 75	498	494	12	14
Tennessee	82	39	2	1	--	1	84	41	115	62	5	8	--	--
Utah	6	3	12	13	3	--	21	16	r 19	r 8	37	35	3	3
Virginia	r 207	207	r 52	1 67	r 57	16	316	290	314	294	161	180	8	11
Washington	1	1	--	--	--	--	1	1	1	1	--	--	--	--
West Virginia	206	199	134	148	88	88	428	435	r 753	r 697	685	673	15	18
Wyoming	3	3	1	1	--	--	4	4	4	5	3	3	--	--
Grand total	r 971	890	r 390	1 415	r 196	147	1,557	1,452	r 2,208	r 2,015	1,849	1,866	40	50

r Revised.
[1] Includes 3 mines using longwall machines only.

Table 28.—Production at underground bituminous coal mines, by State and method of loading

(Thousand short tons)

State	Hand-loaded		Mechanically loaded		Total underground production [1]	
	1972	1973	1972	1973	1972	1973
Alabama	61	42	7,527	7,576	7,588	7,618
Arkansas	8	3	--	--	8	3
Colorado	17	13	3,053	3,347	3,070	3,361
Illinois	--	--	31,721	32,570	31,721	32,570
Indiana	--	--	1,446	789	1,446	789
Iowa	--	--	352	356	352	356
Kentucky:						
Eastern	1,617	1,012	36,329	39,540	37,946	40,553
Western	--	--	18,547	22,342	18,547	22,342
Total [1]	1,617	1,012	54,877	61,883	56,494	62,895
Maryland	7	--	135	66	141	66
Montana	9	1	7	--	17	1
New Mexico	--	--	1,014	733	1,014	733
Ohio	10	--	16,260	16,225	16,269	16,225
Oklahoma	--	--	88	--	88	--
Pennsylvania	135	104	48,998	46,103	49,133	46,207
Tennessee	179	40	5,687	3,596	5,866	3,636
Utah	--	--	4,770	5,500	4,770	5,500
Virginia	27	270	23,967	23,167	23,993	23,437
Washington	--	--	29	16	29	16
West Virginia	901	482	100,762	95,034	101,662	95,516
Wyoming	3	3	438	422	442	425
Grand total [1]	2,974	1,970	301,129	297,384	304,103	299,353

[1] Data may not add to totals shown because of independent rounding.

Table 29.—Mechanical cleaning at bituminous coal and lignite mines, in 1973, by State

(Thousand short tons)

State	Total production	Mechanical cleaning			
		Number of cleaning plants	Raw coal	Cleaned coal	Refuse
Alabama	19,230	19	18,433	11,705	6,728
Alaska	694	1	70	50	20
Colorado	6,233	3	1,933	1,662	270
Illinois	61,572	36	62,386	48,091	14,295
Indiana	25,253	10	25,330	19,699	5,631
Kentucky:					
Eastern	73,966	33	30,359	22,264	8,095
Western	53,679	18	26,004	20,005	5,999
Total	127,645	51	56,363	42,269	14,094
Ohio	45,783	17	20,799	14,588	6,211
Oklahoma	2,183	3	381	312	69
Pennsylvania	76,403	68	63,041	45,731	17,310
Tennessee	8,219	2	1,575	1,145	430
Utah	5,500	7	4,156	3,575	581
Virginia	33,961	32	26,559	17,696	8,863
Washington	3,270	2	4,460	3,262	1,198
West Virginia	115,448	124	107,520	75,672	31,848
Other States [1]	60,344	7	4,639	3,460	1,179
Grand total [2]	591,738	382	397,646	288,918	108,728

[1] Includes Arizona, Arkansas, Iowa, Kansas, Maryland, Missouri, Montana (bituminous coal and lignite), New Mexico, North Dakota (lignite), Texas (lignite), and Wyoming.
[2] Data may not add to totals shown because of independent rounding.

Table 30.—Mechanical cleaning of bituminous coal and lignite, by type of equipment

(Thousand short tons)

Type of equipment	1972	1973
Wet methods:		
Jigs	r 130,331	132,655
Concentrating tables	r 38,232	34,935
Classifiers	2,980	3,297
Launders	5,467	5,121
Dense medium processes:		
Magnetite	r 74,073	74,605
Sand	15,273	12,617
Calcium chloride	r 1,712	981
Total [1]	r 91,058	88,203
Flotation	r 13,050	14,201
Total, wet methods [1]	281,119	278,413
Pneumatic methods	11,710	10,505
Grand total [1]	292,829	288,918

r Revised.
[1] Data may not add to totals shown because of independent rounding.

Table 31.—Mechanical cleaning at bituminous coal and lignite mines, by State, and type of mining

(Thousand short tons)

State	Underground mines		Strip mines		Auger mines		Total, all mines [1]	
	Total production	Cleaned	Total production	Cleaned	Total production	Cleaned	Total production	Cleaned
Alabama	7,618	7,613	11,529	4,009	84	84	19,230	11,705
Alaska	--	--	694	50	--	--	694	50
Colorado	3,361	1,662	2,834	--	38	--	6,233	1,662
Illinois	32,570	22,990	29,002	25,100	--	--	61,572	48,091
Indiana	789	82	24,465	19,616	--	--	25,253	19,699
Kentucky:								
Eastern	40,553	21,563	23,671	489	9,742	211	73,966	22,264
Western	22,342	8,286	31,337	11,719	--	--	53,679	20,005
Total	62,895	29,849	55,008	12,208	9,742	211	127,645	42,269
Ohio	16,225	10,138	28,527	4,450	1,031	--	45,783	14,588
Oklahoma	--	--	2,183	312	--	--	2,183	312
Pennsylvania	46,207	38,479	29,829	7,248	366	4	76,403	45,781
Tennessee	3,636	1,145	4,236	--	348	--	8,219	1,145
Utah	5,500	3,575	--	--	--	--	5,500	3,575
Virginia	23,437	17,696	8,700	--	1,824	--	33,961	17,696
Washington	16	16	3,254	3,246	--	--	3,270	3,262
West Virginia	95,516	71,914	17,704	3,479	2,228	279	115,448	75,672
Other States [2]	1,584	806	58,680	2,653	79	--	60,344	3,460
Grand total [1]	299,353	205,967	276,645	82,372	15,739	579	591,738	288,918

[1] Data may not add to totals shown because of independent rounding.
[2] Includes Arizona, Arkansas, Iowa, Kansas, Maryland, Missouri, Montana (bituminous and lignite), New Mexico, North Dakota (lignite), Texas (lignite), and Wyoming.

Table 32.—Mechanical crushing of bituminous coal and lignite at mines, by State

State	Number of plants crushing coal		Coal crushed (thousand short tons)	
	1972	1973	1972	1973
Alabama	22	27	13,879	13,741
Alaska	1	1	526	644
Arizona	1	1	2,954	3,247
Arkansas	5	5	383	416
Colorado	17	15	7,942	5,814
Illinois	43	47	56,171	57,316
Indiana	23	25	25,259	24,328
Iowa	9	10	696	454
Kansas	2	2	1,219	1,079
Kentucky	148	104	74,139	61,243
Maryland	9	5	523	621
Missouri	7	5	2,958	1,831
Montana:				
Bituminous	3	2	7,109	6,225
Lignite	1	1	320	313
Total	4	3	7,429	6,538
New Mexico	4	4	8,007	8,142
North Dakota (lignite)	9	8	4,710	5,186
Ohio	95	72	32,276	27,589
Oklahoma	9	8	791	2,133
Pennsylvania	149	188	57,512	59,642
Tennessee	25	19	3,456	3,235
Utah	12	9	4,130	4,868
Virginia	58	51	20,584	20,636
Washington	3	2	2,634	3,262
West Virginia	257	235	106,334	91,236
Wyoming	13	13	10,902	11,993
Grand total	925	859	445,414	415,194

Table 33.—Thermal drying of bituminous coal and lignite, by type of drying equipment

Type of dryer	Number of thermal drying units		Thermally dried (thousand short tons)	
	1972	1973	1972	1973
Fluidized-bed	79	66	34,118	30,907
Multilouver	17	16	2,861	1,616
Rotary	40	36	6,924	5,519
Screen	14	12	2,776	2,484
Suspension or flash	31	31	6,098	5,575
Vertical tray and cascade	3	1	459	100
Total [1]	184	162	53,235	46,202

[1] Data may not add to totals shown because of independent rounding.

Table 34.—Comparison of thermal drying of bituminous coal and lignite with mechanical cleaning at mines, by State

(Thousand short tons)

State	Number of cleaning plants: Total		Number of cleaning plants: With thermal drying		Production mechanically cleaned		Thermally dried	
	1972	1973	1972	1973	1972	1973	1972	1973
Alabama	20	19	1	1	11,690	11,705	1,254	818
Colorado	3	3	1	1	1,240	1,662	324	391
Illinois	38	36	9	7	48,837	48,091	7,163	5,155
Indiana	11	10	1	2	19,577	19,699	1,337	2,181
Kentucky:								
Eastern	32	33	13	9	20,382	22,264	3,936	3,358
Western	18	18	2	3	18,226	20,005	297	547
Total [1]	50	51	15	12	38,608	42,269	4,233	3,904
North Dakota (lignite)	--	--	2	2	--	--	164	115
Ohio	21	17	4	4	14,163	14,588	1,275	1,381
Pennsylvania	71	68	13	9	45,612	45,731	5,569	5,393
Utah	7	7	2	1	3,333	3,575	720	982
Virginia	31	32	10	10	17,763	17,696	4,496	4,421
West Virginia	136	124	54	45	83,325	75,672	26,700	21,461
Other States	20	15	--	--	8,683	8,230	--	--
Total [1]	408	382	112	94	292,829	288,918	53,235	46,202

[1] Data may not add to totals shown because of independent rounding.

Table 35.—Thermal drying of bituminous coal and lignite at mines, by State

(Thousand short tons)

State	Number of thermal drying units		Grand total production		Thermally dried	
	1972	1973	1972	1973	1972	1973
Alabama	3	3	20,814	19,230	1,254	818
Colorado	1	1	5,522	6,233	324	391
Illinois	24	11	65,523	61,572	7,163	5,155
Indiana	7	11	25,949	25,253	1,337	2,181
Kentucky:						
Eastern	15	11	68,858	73,966	3,936	3,358
Western	5	7	52,330	53,679	297	547
Total [1]	20	18	121,187	127,645	4,233	3,904
North Dakota (lignite)	2	2	6,632	6,906	164	115
Ohio	8	13	50,967	45,783	1,275	1,381
Pennsylvania	21	13	75,939	76,403	5,569	5,393
Utah	2	1	4,802	5,500	720	982
Virginia	20	21	34,028	33,961	4,496	4,421
West Virginia	76	68	123,743	115,448	26,700	21,461
Other States	--	--	60,280	67,805	--	--
Total [1]	184	162	595,386	591,738	53,235	46,202

[1] Data may not add to totals shown because of independent rounding.

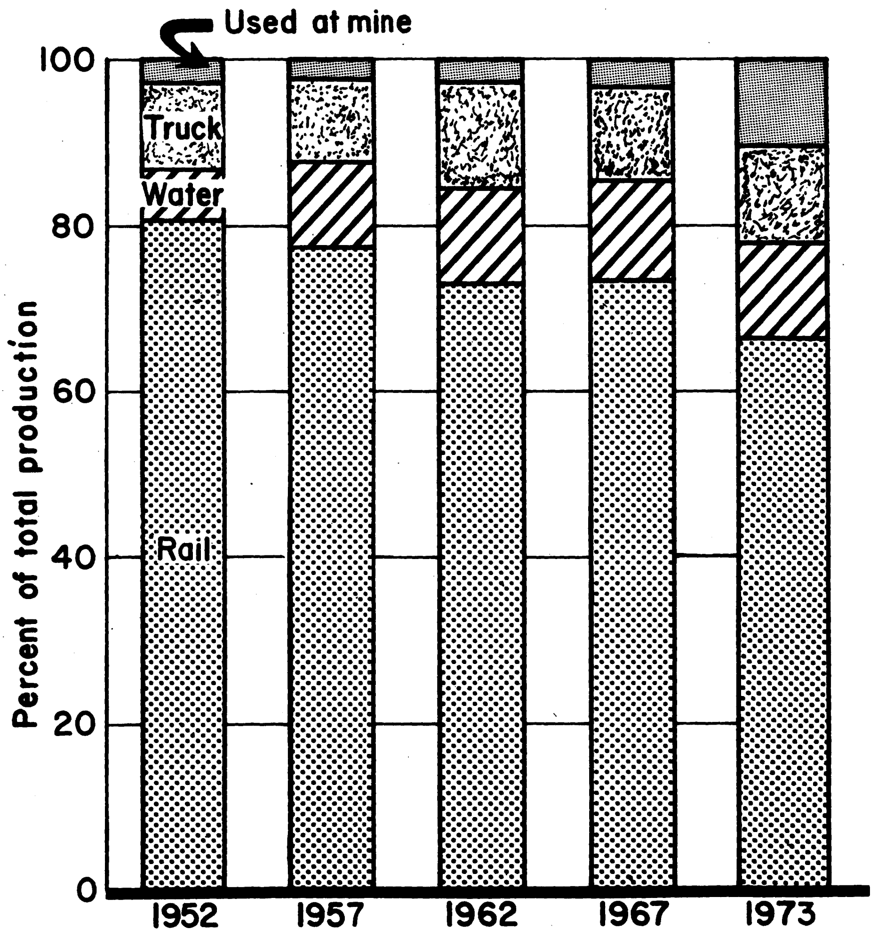

Figure 5.—Percentage of total production of bituminous coal and lignite, by method of shipment from mines and percentage used at mines.

Table 36.—Bituminous coal and lignite loaded for shipment by railroads and waterways in the United States, in 1973, as reported by mine operators

(Thousand short tons)

Route	State	By State	Total for route [1]
RAILROAD			
Alaska	Alaska	579	579
Atchison, Topeka & Santa Fe	Illinois	45	1,436
	New Mexico	1,391	
Baltimore & Ohio	Illinois	1,099	24,561
	Maryland	169	
	Ohio	6,172	
	Pennsylvania	3,000	
	West Virginia	14,121	
Bevier & Southern	Missouri	720	720
Bessemer & Lake Erie	Pennsylvania	2,522	2,522
Burlington Northern	Illinois	8,821	23,884
	Iowa	89	
	Missouri	72	
	Montana (Bit. and Lig.)	10,647	
	North Dakota (Lig.)	2,877	
	Wyoming	1,378	
Cambria & Indiana	Pennsylvania	3,274	3,274
Carbon County	Utah	2,407	2,407
Chesapeake & Ohio	Kentucky	28,979	60,898
	Ohio	944	
	West Virginia	30,925	
Chicago & Eastern Illinois	Illinois	2,907	2,907
Chicago & Illinois Midland	do	1,161	1,161
Chicago, Milwaukee, St. Paul and Pacific	Indiana	3,455	3,607
	Montana (Bit. and Lig.)	5	
	North Dakota (Lig.)	147	
Chicago & North Western	Illinois	3,827	3,827
Chicago, Rock Island & Pacific	Iowa	46	46
Clinchfield	Kentucky	371	5,617
	Virginia	5,246	
Colorado & Wyoming	Colorado	624	624
Denver & Rio Grande Western	Colorado	4,021	4,769
	Utah	748	
Erie-Lackawanna	Ohio	94	94
Gulf, Mobile & Ohio	Illinois	2,986	2,986
Illinois Central	Illinois	22,025	34,055
	Kentucky	12,030	
Interstate	Virginia	3,196	3,196
Kansas City Southern	Oklahoma	190	190
Kentucky & Tennessee	Kentucky	443	443
Lake Erie, Franklin & Clarion	Pennsylvania	121	121
Louisville & Nashville	Alabama	3,572	42,234
	Indiana	3,805	
	Kentucky	33,706	
	Tennessee	1,081	
	Virginia	70	
Mary Lee	Alabama	726	726
Missouri Illinois	Illinois	2,209	2,209
Missouri-Kansas-Texas	Kansas	712	1,181
	Missouri	468	
	Oklahoma	1	
Missouri Pacific	Arkansas	240	4,546
	Illinois	4,128	
	Oklahoma	178	
Monongahela	West Virginia	6,899	6,899
Montour	Pennsylvania	2,721	2,721
Norfolk & Western	Iowa	26	67,220
	Kentucky	14,516	
	Ohio	5,493	
	Virginia	18,957	
	West Virginia	28,228	
Penn Central (includes coal shipped over Kanawha & Michigan, Kelley's Creek, Toledo & Ohio Central and Zanesville & Western)	Illinois	2,342	45,273
	Indiana	7,686	
	Ohio	9,577	
	Pennsylvania	19,331	
	West Virginia	6,337	
Pittsburgh & Shawmut	Pennsylvania	2,170	2,170
St. Louis-San Francisco	Alabama	253	2,193
	Arkansas	9	
	Kansas	297	
	Oklahoma	1,634	
Soo Line	North Dakota (Lig.)	681	681
Southern	Alabama	4,582	16,719
	Indiana	2,305	
	Kentucky	738	
	Tennessee	3,889	
	Virginia	5,205	

See footnotes at end of table.

Table 36.—Bituminous coal and lignite loaded for shipment by railroads and waterways in the United States, in 1973, as reported by mine operators—Continued

(Thousand short tons)

Route	State	By State	Total for route[1]
RAILROAD—Continued			
Tennessee	Tennessee	58	58
Tennessee Coal, Iron & Railroad Co	Alabama	1,574	1,574
Union Pacific	Colorado	208	7,930
	Wyoming	7,722	
Utah	Utah	847	847
Western Maryland	Maryland	1,066	5,242
	Pennsylvania	1,055	
	West Virginia	3,118	
Woodward Iron Co	Alabama	842	842
Yankeetown	Indiana	1,961	1,961
Total railroad shipments[1]		397,158	397,158
WATERWAY			
Allegheny River	Pennsylvania	710	710
Arkansas River	Arkansas	165	222
	Oklahoma	57	
Big Sandy River	Kentucky	109	109
Black Warrior River	Alabama	2,743	2,743
Cumberland River	Kentucky	63	63
Green River	do	14,018	14,018
Illinois River	Illinois	291	291
Kanawha River	West Virginia	3,764	3,764
Monongahela River	Pennsylvania	16,257	24,488
	West Virginia	8,231	
Ohio River	Illinois	1,868	21,613
	Indiana	1,917	
	Kentucky	7,680	
	Ohio	6,539	
	Pennsylvania	59	
	West Virginia	3,550	
Tennessee River	Alabama	10	583
	Tennessee	573	
Total waterway shipments		68,604	68,604
Total loaded at mines for shipment by railroads and waterways		465,762	465,762
Shipped by truck from mine to final destination		57,268	57,268
Coal transported to electric utility plants adjacent to or near the mine		64,424	64,424
All other[2]		4,284	4,284
Toal production		591,738	591,738

[1] Data may not add to totals shown because of independent rounding.
[2] Includes coal used at mine for power and heat, made into beehive coke at mine, used by mine employees, used for all other purposes at mine, shipped by slurry pipeline.

Table 37.—Bituminous coal and lignite shipped by unit train in the United States

(Thousand short tons)

State	1972	1973
Alabama	4,253	3,930
Colorado	1,210	2,391
Illinois	21,777	22,155
Indiana	3,048	5,493
Iowa	378	--
Kansas	214	190
Kentucky:		
Eastern	9,522	12,197
Western	6,706	7,291
Total[1]	16,228	19,489
Maryland	60	122
Montana (bituminous)	7,698	10,115
New Mexico	623	778
North Dakota (lignite)	1,577	1,607
Ohio	18,063	18,266
Oklahoma	462	489
Pennsylvania	18,228	22,262
Tennessee	1,171	1,208
Utah	1,905	2,094
Virginia	3,301	4,477
West Virginia	33,449	34,203
Wyoming	2,889	5,826
Total	136,534	155,093

[1] Data may not add to totals shown because of independent rounding.

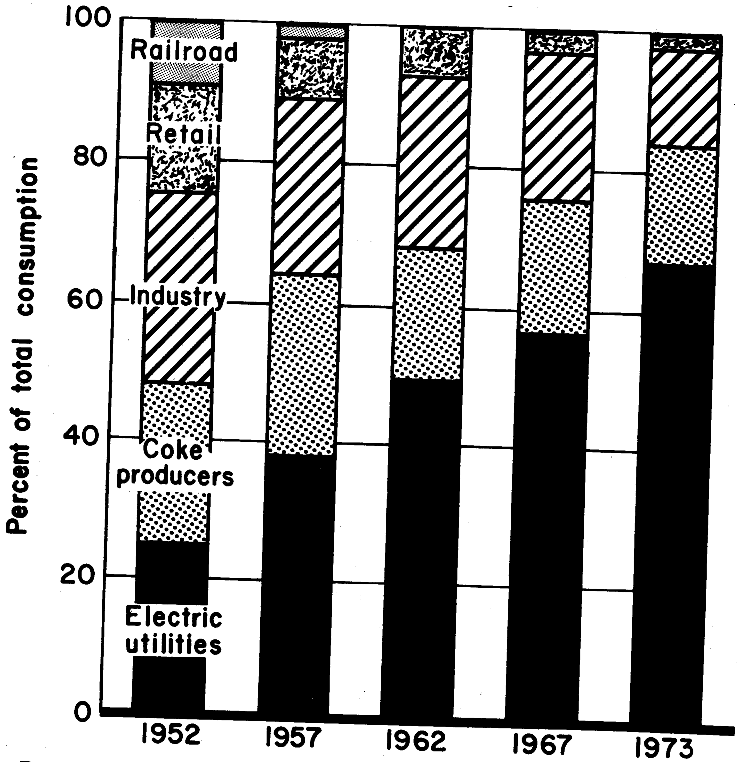

Figure 6.—Percentage of total consumption of bituminous coal and lignite, by consumer class and retail deliveries in the United States.

Table 38.—Consumption of bituminous coal and lignite, by consumer class, and retail deliveries in the United States

(Thousand short tons)

Year and month	Electric power utilities [1]	Bunker lake vessel and foreign [2]	Manufacturing and mining industries: Beehive coke plants	Oven coke plants	Steel and rolling mills [3]	Other manufacturing and mining industries [4]	Retail deliveries to other consumers [5]	Total of classes shown
1969	308,461	313	1,158	91,743	5,560	85,374	14,666	507,275
1970	318,921	298	1,428	94,581	5,410	82,909	12,072	515,619
1971	326,280	207	1,278	81,531	5,560	68,655	11,351	494,862
1972:								
January	30,074	1	82	6,790	510	5,190	1,304	43,951
February	28,790	--	86	6,689	540	6,075	998	43,178
March	28,261	2	85	7,373	492	6,817	743	43,773
April	25,908	11	85	7,338	416	5,998	402	40,158
May	26,648	20	82	7,557	378	5,580	323	40,588
June	27,600	23	84	7,126	244	5,166	262	40,505
July	30,088	18	79	7,276	290	4,970	350	43,071
August	31,470	24	87	7,273	298	4,969	577	44,698
September	28,800	20	88	6,952	306	4,996	840	42,002
October	28,967	17	87	7,258	381	5,438	902	43,050
November	29,720	19	102	7,063	457	5,772	971	44,104
December	32,286	8	112	7,518	538	6,160	1,076	47,698
Total	348,612	163	1,059	86,213	4,850	67,131	8,748	516,776
1973: p								
January	34,175	--	102	7,718	656	6,029	1,158	49,838
February	30,425	--	99	7,083	577	5,540	928	44,652
March	30,533	2	103	7,847	540	5,106	683	44,814
April	28,868	13	102	7,625	525	5,160	396	42,689
May	29,655	17	106	7,943	550	4,997	360	43,628
June	31,824	15	96	7,678	558	4,563	381	45,115
July	34,620	13	101	7,863	450	4,237	431	47,715
August	35,933	14	113	7,781	425	4,128	446	48,840
September	32,735	12	105	7,498	430	4,019	672	45,471
October	32,263	12	132	7,755	410	5,051	804	46,427
November	31,962	11	124	7,612	575	5,487	932	46,703
December	33,886	7	127	7,921	660	6,520	1,009	50,130
Total	386,879	116	1,310	92,324	6,356	60,837	8,200	556,022

p Preliminary.
[1] Federal Power Commission.
[2] Bureau of the Census, U.S. Department of Commerce, Ore and Coal Exchange.
[3] Estimates based upon reports collected from a selected list of representative steel and rolling mills.
[4] Estimates based upon reports collected from a selected list of representative manufacturing plants.
[5] Estimates based upon reports collected from a selected list of representative retailers. Includes some coal shipped by truck from mine to final destination.

Table 39.—Stocks of bituminous coal and lignite held by commercial consumers and in retail dealer's yards in the United States, 1973

Date	Total stocks (thousand short tons)	Days' supply at current rate of consumption on date of stocktaking: Electric power utilities	Oven coke plants	Steel and rolling mills	Other manufacturing and mining industries	Retail dealers	Average
Jan. 31	111,120	82	34	17	49	6	69
Feb. 28	108,870	82	33	16	53	6	68
Mar. 31	111,490	94	33	24	62	11	77
Apr. 30	112,585	96	33	23	60	19	79
May 31	116,890	102	34	24	61	24	83
June 30	109,960	86	33	32	65	16	73
July 31	107,390	81	24	32	72	14	70
Aug. 31	106,910	78	26	31	72	16	68
Sept. 30	106,230	81	26	34	75	11	70
Oct. 31	107,490	86	28	30	58	8	72
Nov. 30	107,110	84	28	24	51	9	69
Dec. 31	102,200	78	27	19	43	9	63

Table 40.—Distribution of bituminous coal and lignite, in 1973, by method of movement and consumer use

(Thousand short tons)

Shipments	Electric utilities	Coke and gas plants	Retail dealers	All others	Rail-road fuel	Used at mines and sales to employees
Shipments to all destinations in the United States, Canada, and Mexico, by specific method of movement and consumer use:						
Method of movement:						
All-rail	195,008	54,285	4,431	[1] 36,329	--	--
River and ex-river	76,490	23,203	277	4,709	--	--
Great Lakes [2]	17,628	13,767	975	6,478	--	--
Tidewater [3]	2,357	4,955	--	43	--	--
Truck	48,397	1,724	2,332	15,661	--	--
Tramway, conveyor, and private railroad	42,284	61	--	1,860	--	--
Method of movement and/or consumer uses unknown	--	--	--	--	229	1,600
Total	382,164	97,995	8,015	[1] 65,080	229	1,600

Shipments	Canadian Great Lakes commercial docks [4]	U.S. Great Lakes dock storage [4]	U.S. tidewater dock storage [4]	Overseas exports [5] [6]	Net change in mine inventory	Total
Shipments to all destinations in the United States, Canada, and Mexico by specific method of movement and consumer use:						
Method of movement:						
All-rail	--	--	--	--	--	[1] 290,053
River and ex-river	--	--	--	--	--	104,679
Great Lakes [2]	--	--	--	--	--	38,848
Tidewater [3]	--	--	--	--	--	7,355
Truck	--	--	--	--	--	68,114
Tramway, conveyor, and private railroad	--	--	--	--	--	44,205
Method of movement and/or consumer uses unknown	174	−117	--	35,570	−922	36,524
Total	174	−117	--	35,570	−922	589,788

[1] Includes overseas exports from producing districts 13 and 14.
[2] Excludes shipments to Canadian Great Lakes commercial docks and U.S. dock storage for which consumer uses are not available; however, includes vessel fuel, the destinations of which are not available.
[3] Excludes overseas exports for which consumer uses are not available.
[4] Consumer use unknown.
[5] Excludes Canada; consumer use unknown.
[6] Excludes overseas exports from producing districts 13 and 14.

Table 41.—Distribution of bituminous coal and lignite, in 1973, by district of origin consumer use

(Thousand short tons)

District of origin[1]	Electric utilities	Coke and gas plants	Retail dealers	All others	Railroad fuel	Used at mines and sales to employees
1	34,362	5,135	394	4,001	23	224
2	9,403	20,643	224	3,518	--	11
3 and 6	34,818	2,677	166	3,382	10	7
4	38,926	--	891	7,203	18	27
7	789	14,388	280	1,284	50	1,030
8	65,747	38,969	4,114	21,491	110	104
9	52,894	--	200	3,084	3	--
10	49,705	4,438	663	7,736	8	44
11	20,454	--	109	4,492	3	--
12	618	--	3	37	--	--
13	11,628	5,879	166	[2] 2,527	--	--
14	--	271	--	[2] 502	--	--
15	12,665	164	22	2,296	1	1
16	492	--	9	7	--	2
17	2,974	3,263	202	464	--	2
18	11,008	--	--	29	--	--
19	14,113	61	71	783	1	7
20	1,903	2,107	398	1,106	1	25
21	6,098	--	87	623	--	116
22 and 23	13,567	--	16	515	1	--
Total	382,164	97,995	8,015	65,080	229	1,600

District of origin[1]	Canadian Great Lakes commercial docks[3]	U.S. Great Lakes dock storage[3]	U.S. tidewater dock storage[3]	Overseas exports[4]	Net change in mine inventory	Total
1	49	--	--	2,738	181	47,107
2	40	--	--	--	−154	33,685
3 and 6	53	−9	--	1,716	−251	42,569
4	8	−1	--	--	643	47,715
7	--	--	--	13,421	−63	31,179
8	24	−107	--	17,695	−708	147,439
9	--	--	--	--	88	56,269
10	--	--	--	--	−644	61,950
11	--	--	--	--	−48	25,010
12	--	--	--	--	--	658
13	--	--	--	(5)	−69	20,131
14	--	--	--	(5)	--	773
15	--	--	--	--	−120	15,029
16	--	--	--	--	−1	509
17	--	--	--	--	53	6,958
18	--	--	--	--	81	11,118
19	--	--	--	--	39	15,075
20	--	--	--	--	58	5,598
21	--	--	--	--	−6	6,918
22 and 23	--	--	--	--	−1	14,098
Total	174	−117	--	35,570	−922	589,788

[1] Producing districts are defined in Bureau of Mines Bituminous Coal and Lignite Distribution Calendar Year 1973, Mineral Industry Survey, Apr. 12, 1974, 41 pp.
[2] Includes overseas exports.
[3] Consumer use unknown.
[4] Excludes Canada; consumer use unknown.
[5] Included with all others.

Table 42.—Distribution of bituminous coal and lignite, in 1973, by destination and consumer use

(Thousand short tons)

Destination	Total	Electric utilities	Coke and gas plants	Retail dealers	All others [1]
New England:					
Massachusetts	106	22	--	23	61
Connecticut	118	69	--	--	49
Maine, New Hampshire, Vermont, Rhode Island	1,109	1,071	--	7	31
Middle Atlantic:					
New York	13,290	5,469	5,444	59	2,318
New Jersey	2,524	2,425	--	21	78
Pennsylvania	64,469	34,963	23,177	657	5,672
East North Central:					
Ohio	65,557	41,745	13,410	1,056	9,346
Indiana	45,061	25,753	13,605	450	5,253
Illinois	40,628	32,465	2,968	934	4,261
Michigan	31,685	20,294	4,876	561	5,954
Wisconsin	12,634	9,322	239	458	2,615
West North Central:					
Minnesota	9,161	6,862	1,082	247	970
Iowa	6,889	5,359	--	71	1,459
Missouri	17,385	15,451	319	191	1,424
North Dakota and South Dakota	5,816	5,381	--	114	321
Nebraska and Kansas	3,527	3,086	--	27	414
South Atlantic:					
Delaware and Maryland	10,596	4,789	4,850	32	925
District of Columbia	548	265	--	24	259
Virginia	7,910	4,944	--	450	2,516
West Virginia	32,305	22,502	5,196	243	4,364
North Carolina	19,820	17,999	--	381	1,440
South Carolina	6,999	5,663	--	230	1,106
Georgia and Florida	16,894	16,434	--	72	388
East South Central:					
Kentucky	25,078	21,734	1,162	314	1,868
Tennessee	22,238	19,588	193	358	2,099
Alabama and Mississippi	27,695	18,189	7,105	90	2,311
West South Central: Arkansas, Louisiana, Oklahoma, and Texas	8,049	4,840	953	4	2,252
Mountain:					
Colorado	6,490	4,672	1,114	168	536
Utah	3,957	1,202	1,814	187	754
Montana and Idaho	1,395	889	--	211	295
Wyoming	6,200	5,932	--	22	246
New Mexico	7,343	7,325	--	--	18
Arizona and Nevada	4,451	4,313	--	1	137
Pacific:					
Washington and Oregon	3,510	3,246	--	32	232
California	2,398	--	2,385	--	13
Alaska	707	231	--	13	463
Canada [2]	16,052	7,439	7,376	270	967
Mexico	305	--	126	--	179
Destinations not revealable	1,755	231	601	37	[3] 886
Destinations and/or consumer uses not available:					
Great Lakes movement:					
Canadian commercial docks	174	--	--	--	--
Vessel fuel	600	--	--	--	--
U.S. dock storage	—117	--	--	--	--
Tidewater movement:					
Overseas exports (except Canada)	[4] 35,570	--	--	--	--
Bunker fuel	--	--	--	--	--
U.S. dock storage	--	--	--	--	--
Railroad fuel:					
U.S. companies	224	--	--	--	--
Canadian companies	5	--	--	--	--
Coal used at mines and sales to employees	1,600	--	--	--	--
Net change in mine inventory	—922	--	--	--	--
Total	589,788	--	--	--	--

[1] Excludes vessel fuel and bunker fuel, the destinations of which are not available.
[2] Excludes shipments to Canadian Great Lakes commercial docks and Canadian railroad companies.
[3] Includes overseas exports from producing districts 13 and 14.
[4] Excludes overseas exports from producing districts 13 and 14.

Table 43.—Total bituminous coal and lignite shipments and percent of grand total shipments, by geographic division and State of destination

Geographic division and State of destination	Thousand short tons					Percent of total				
	1969	1970	1971	1972	1973	1969	1970	1971	1972	1973
Total	559,880	597,992	553,123	595,214	589,788	100.0	100.0	100.0	100.0	100.0
New England	5,659	3,568	2,445	1,522	1,333	1.0	.6	.4	.2	.2
Massachusetts	2,225	608	227	147	106	.4	.1	(1)	(1)	(1)
Connecticut	2,295	1,832	1,271	109	118	.4	.3	.2	(1)	(1)
Maine, New Hampshire, Vermont, and Rhode Island	1,139	1,128	947	1,266	1,109	.2	.2	.2	.2	.2
Middle Atlantic	89,485	90,992	77,552	78,998	80,283	16.0	15.2	14.0	13.2	13.6
New York	24,324	23,032	15,596	13,177	13,290	4.3	3.9	2.8	2.2	2.3
New Jersey	5,500	4,951	2,974	1,303	2,524	1.0	.8	.5	.2	.4
Pennsylvania	59,661	63,009	58,982	64,518	64,469	10.7	10.5	10.7	10.8	10.9
East North Central	199,349	206,011	187,969	206,504	195,565	35.6	34.5	34.0	34.7	33.2
Ohio	62,160	67,375	63,116	67,795	65,557	11.1	11.3	11.4	11.4	11.1
Indiana	41,299	42,385	38,599	46,618	45,061	7.4	7.1	7.0	7.8	7.6
Illinois	45,244	42,310	38,289	42,028	40,628	8.1	7.1	6.9	7.1	6.9
Michigan	35,674	36,633	32,625	35,085	31,685	6.3	6.1	5.9	5.9	5.4
Wisconsin	14,972	17,308	15,340	14,978	12,634	2.7	2.9	2.8	2.5	2.2
West North Central	30,337	35,098	35,407	39,587	42,778	5.4	5.9	6.4	6.7	7.3
Minnesota	8,100	8,769	8,313	8,639	9,161	1.4	1.5	1.5	1.4	1.6
Iowa	5,673	6,159	6,239	6,956	6,889	1.0	1.0	1.1	1.2	1.2
Missouri	11,098	13,397	13,358	15,810	17,385	2.0	2.3	2.4	2.7	2.9
North Dakota and South Dakota	3,996	4,799	5,272	5,834	5,816	.7	.8	1.0	1.0	1.0
Nebraska and Kansas	1,470	1,974	2,225	2,348	3,527	.3	.3	.4	.4	.6
South Atlantic	89,574	91,559	90,354	96,907	95,072	16.0	15.3	16.3	16.3	16.1
Delaware and Maryland	15,008	13,928	11,599	9,744	10,596	2.7	2.3	2.1	1.6	1.8
District of Columbia	1,235	1,113	598	458	548	.2	.2	.1	.1	.1
Virginia	12,994	11,065	9,258	8,027	7,910	2.3	1.9	1.7	1.3	1.3
West Virginia	24,356	24,395	26,606	32,459	32,305	4.4	4.1	4.8	5.5	5.5
North Carolina	18,711	21,696	19,779	21,489	19,820	3.3	3.6	3.6	3.6	3.8
South Carolina	5,319	6,143	6,219	6,915	6,999	1.0	1.0	1.1	1.2	1.2
Georgia and Florida	11,951	13,219	16,295	17,815	16,894	2.1	2.2	2.9	3.0	2.9
East South Central	62,730	69,185	72,191	78,843	75,011	11.2	11.6	13.0	13.2	12.7
Kentucky	20,355	23,672	25,590	27,389	25,078	3.6	4.0	4.6	4.6	4.2
Tennessee	16,793	18,315	18,907	21,390	22,238	3.0	3.1	3.4	3.6	3.8
Alabama and Mississippi	25,582	27,198	27,694	30,064	27,695	4.6	4.5	5.0	5.0	4.7
West South Central: Arkansas, Louisiana, Oklahoma, and Texas	929	1,144	887	930	8,049	.2	.2	.2	.2	1.4
Mountain	16,418	20,232	21,581	26,330	29,836	2.9	3.4	3.9	4.4	5.1
Colorado	4,687	5,136	4,475	5,516	6,490	.8	.9	.8	.9	1.1
Utah	2,978	3,010	2,993	3,017	3,957	.5	.5	.5	.5	.7
Montana and Idaho	1,063	1,065	1,348	1,281	1,395	.2	.2	.3	.2	.2
Wyoming	3,324	3,809	3,728	5,152	6,200	.6	.6	.7	.9	1.1
New Mexico	3,263	6,032	6,713	6,851	7,343	.6	1.0	1.2	1.1	1.2
Arizona and Nevada	1,103	1,180	2,324	4,513	4,451	.2	.2	.4	.8	.8

See footnotes at end of table.

Table 43.—Total bituminous coal and lignite shipments and percent of grand total shipments, by geographic division and State and destination—Continued

Geographic division and State of destination	Thousand short tons 1969	1970	1971	1972	1973	Percent of total 1969	1970	1971	1972	1973
Pacific	2,683	2,691	3,329	4,645	5,908	.5	.5	.6	.8	1.0
Washington and Oregon	452	374	1,482	2,865	3,510	.1	.1	.3	.5	.6
California	2,231	2,317	1,847	1,780	2,398	.4	.4	.3	.3	.4
Alaska	672	612	748	707	707	.1	.1	.1	.1	.1
Canada [2]	16,752	18,673	17,522	18,162	16,231	3.0	3.1	3.2	3.1	2.7
Mexico	84	163	291	466	305	(1)	(1)	.1	.1	.1
Destinations not revealable	2,175	[3] 2,969	[4] 2,179	[5] 1,702	[6] 1,755	.4	[3] .5	[4] .4	[5] .3	[6] .3
U.S. railroad fuel	827	721	528	357	224	.1	.1	.1	.1	(1)
U.S. Great Lakes storage	−446	−16	−263	−266	−117	−.1	(1)	(1)	(1)	(1)
Vessel fuel	951	1,072	713	595	600	.2	.2	.1	.1	.1
Overseas exports	39,361	[7] 51,766	[8] 37,810	[9] 36,607	[10] 35,570	7.0	[7] 8.6	[8] 6.8	[9] 6.1	[10] 6.0
Coal used at mines and sales to employees	1,450	1,486	1,483	1,521	1,600	.3	.2	.3	.2	.3
Change in mine inventory	890	66	397	1,097	−922	.2	(1)	.1	.2	−.2

[1] Less than 0.1%.
[2] Includes shipments to Canadian Great Lakes commercial docks and railroad companies.
[3] Includes overseas exports from producing districts 13 and 17.
[4] Includes overseas exports from producing districts 13, 14, 17, and 20.
[5] Includes overseas exports from producing districts 13, 14, and 20.
[6] Includes overseas exports from producing districts 13 and 14.
[7] Excludes overseas exports from producing districts 13 and 17.
[8] Excludes overseas exports from producing districts 13, 14, 17, and 20.
[9] Excludes overseas exports from producing districts 13, 14, and 20.
[10] Excludes overseas exports from producing districts 13 and 14.

Table 44.—Shipments of bituminous coal and lignite in 1973, by average sulfur content and by consumer use

District	Quantity shipped (thousand short tons)						Average sulfur content (percent)					
	Electric utilities	Coke and gas plants	Other industrial uses and retail dealers	All other uses	Exports (overseas and Canada)	Total [1]	Electric utilities	Coke and gas plants	Other industrial uses and retail dealers	All other uses	Exports (overseas and Canada)	Total
1. Eastern Pennsylvania	24,075	4,298	2,547	2,615	1,726	35,261	2.2	1.0	1.9	1.8	1.6	2.0
2. Western Pennsylvania	5,501	12,480	3,116	2,194	640	23,931	2.1	1.5	1.8	1.6	2.1	1.7
3. Northern West Virginia	16,860	1,895	1,656	579	4,239	25,229	2.8	1.2	2.5	2.0	2.1	2.5
4. Ohio	28,508	--	5,866	647	1	35,022	3.5	--	2.6	3.2	2.9	3.4
5. Michigan	--	--	--	--	--	--	--	--	--	--	--	--
6. Panhandle	6,728	--	231	123	27	7,109	3.9	--	3.0	2.8	2.8	3.8
7. Southern Number 1	734	7,376	772	1,260	5,904	16,046	.6	.7	.8	.8	.7	.7
8. Southern Number 2	25,134	19,147	4,657	5,446	6,590	60,974	1.2	.8	.8	.9	.7	1.0
9. West Kentucky	36,188	--	1,436	157	--	37,781	4.1	--	3.9	4.9	--	4.1
10. Illinois	35,833	3,090	7,035	113	--	46,071	3.5	.8	2.9	2.8	--	3.2
11. Indiana	15,893	--	3,902	171	--	19,966	3.4	--	3.4	3.4	--	3.4
12. Iowa	564	--	--	6	--	570	3.5	--	--	4.0	--	3.5
13. Southeastern	8,027	4,616	455	598	569	14,265	1.6	1.0	2.3	.7	1.4	1.4
14. Arkansas-Oklahoma	--	203	242	--	132	577	--	1.7	1.8	--	.6	1.5
15. Southwestern	6,893	58	195	32	--	7,178	5.1	.5	3.8	1.2	--	5.0
16. Northern Colorado	493	--	--	16	--	509	.5	--	--	.3	--	.5
17. Southern Colorado	3,025	1,890	277	65	--	5,257	.6	.6	.6	.5	--	.6
18. New Mexico	11,374	--	10	3	--	11,387	.5	--	.5	.5	--	.5
19. Wyoming	8,204	2	639	32	--	8,877	.5	.7	.7	.5	--	.5
20. Utah	1,747	1,286	1,323	158	--	4,514	.5	.8	.6	.5	--	.7
21. North-South Dakota	5,975	--	774	34	1	6,784	.7	--	.8	1.0	1.5	.7
22. Montana	6,384	--	16	13	--	6,413	.6	--	.9	.6	--	.6
23. Washington	680	--	--	14	--	694	2.0	--	--	2.0	--	2.0
Total United States	248,820	56,341	35,149	14,276	19,829	374,415	2.7	1.0	2.2	1.4	1.1	2.3

[1] Total shipments by producers reporting sulfur content (63% of total U.S. production).

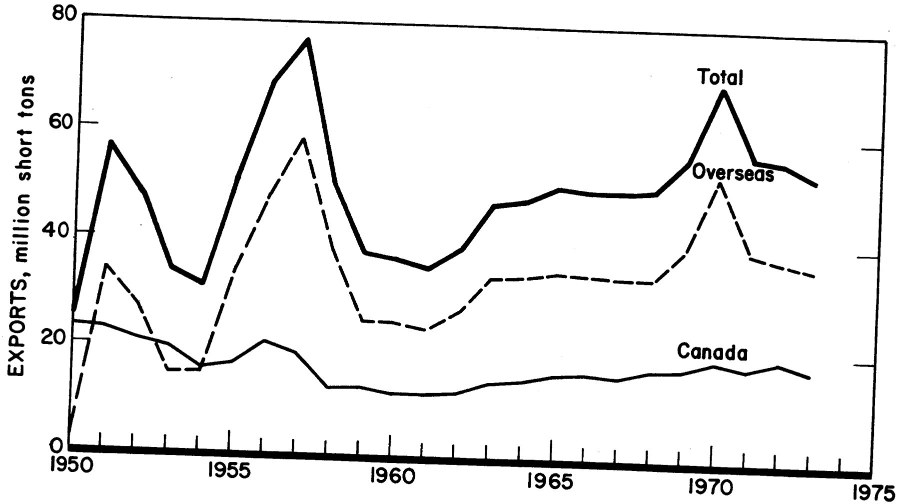

Figure 7.—Exports of bituminous coal and lignite from the United States to Canada and overseas.

Table 45.—Exports of bituminous coal, by country group

(Thousand short tons and thousand dollars)

Country group	1971		1972		1973	
	Quantity	Value	Quantity	Value	Quantity	Value
Canada (including Newfoundland and Mexico)	17,852	208,795	18,627	264,575	16,569	253,011
Overseas (all other countries):						
West Indies and Central America	--	--	--	--	(1)	1
Bermuda, Greenland, Miquelon, St. Pierre Islands	(1)	10	1	17	2	32
South America	2,673	49,092	2,651	51,497	2,654	54,154
Europe	16,403	280,943	16,679	307,647	14,253	290,327
Asia	19,705	352,644	r 18,039	r 349,453	19,381	403,954
Africa	--	--	--	--	(1)	5
Oceania	(1)	(1)	(1)	(1)	44	973
Total	38,781	682,689	r 37,370	r 708,614	36,334	749,446
Grand total	56,633	891,484	r 55,997	r 973,189	52,903	1,002,457

r Revised.

[1] Less than ½ unit.

Table 46.—Bituminous coal exported from the United States, by country[1]

(Thousand short tons and thousand dollars)

Country	1971		1972		1973	
	Quantity	Value	Quantity	Value	Quantity	Value
Australia	(2)	(2)	--	--	44	973
Argentina	539	9,754	394	7,655	772	15,400
Belgium-Luxembourg	765	15,005	1,144	22,214	1,205	25,461
Brazil	1,869	34,619	1,917	37,067	1,645	33,482
Canada	17,565	202,922	18,161	254,243	16,231	246,247
Chile	207	3,843	240	5,315	194	4,481
France	3,106	50,623	1,575	30,632	1,866	39,882
Germany:						
East	77	1,448	19	411	--	--
West	2,911	43,091	2,399	39,780	1,633	30,589
Greece	65	1,130	--	--	33	646
Ireland	17	349	22	416	--	--
Italy	2,680	50,257	3,673	69,584	3,294	64,543
Japan	19,706	352,629	r 18,038	r 349,444	19,190	399,573
Korea, Republic of	--	--	--	--	191	4,377
Mexico	285	5,835	466	10,332	338	6,764
Miquelon and St. Pierre Islands	2	38	--	--	1	22
Netherlands	1,625	27,386	2,289	39,925	1,780	36,111
Norway	83	1,597	167	3,361	126	2,757
Peru	26	277	67	792	22	380
Portugal	12	243	304	5,813	395	8,267
Romania	--	--	--	--	284	5,879
Spain	2,556	48,562	2,139	42,928	2,234	47,252
Sweden	618	12,149	425	8,260	342	6,815
Switzerland	32	433	--	--	--	--
United Kingdom	1,669	25,897	2,381	41,793	941	19,932
Uruguay	31	597	32	653	21	406
Yugoslavia	185	2,774	142	2,530	120	2,193
Other	2	26	3	41	1	25
Total	56,633	891,484	r 55,997	r 973,189	52,903	1,002,457

r Revised.
[1] Amounts stated do not include fuel or bunker coal on vessels engaged in foreign trade, which aggregated 44,010 tons ($676,437) in 1971; 30,718 tons ($545,146) in 1972; and 11,898 tons ($231,789) in 1973.
[2] Less than ½ unit.

Table 47.—Bituminous coal exported from the United States, by customs district

(Thousand short tons and thousand dollars)

Customs district	1971		1972		1973	
	Quantity	Value	Quantity	Value	Quantity	Value
Baltimore	3,374	53,560	3,751	66,061	4,402	85,646
Buffalo	21	280	13	183	13	226
Chicago	57	639	65	759	81	974
Cleveland	17,146	195,975	17,802	248,305	15,933	240,980
Detroit	93	1,624	94	1,676	106	1,888
Duluth	4	85	9	175	7	119
El Paso	53	844	42	721	22	401
Houston	--	--	1	9	--	--
Laredo	231	4,990	424	9,611	315	6,354
Los Angeles	385	4,975	r 174	r 3,826	(1)	3
Mobile	745	10,406	1,142	17,384	1,123	19,277
New Orleans	656	9,271	774	12,300	653	11,734
New York City	(1)	4	(1)	7	1	6
Nogales	--	--	--	--	(1)	9
Norfolk	33,396	603,471	31,585	609,936	30,192	633,815
Ogdensburg	16	262	50	778	23	460
Pembina	8	166	13	256	8	157
Philadelphia	66	1,035	(1)	2	22	377
Port Arthur	380	3,862	57	1,180	--	--
Portland, Oreg	--	--	--	--	(1)	1
San Diego	(1)	(1)	(1)	3	(1)	1
San Francisco	--	--	(1)	2	(1)	3
San Juan	--	--	--	--	(1)	1
Seattle	2	35	1	15	2	25
Total	56,633	891,484	r 55,997	r 973,189	52,903	1,002,457

r Revised.
[1] Less than ½ unit.

Table 48.—Bituminous coal[1] imported for consumption in the United States, by country and customs district

Country and customs district	1971 Quantity (short tons)	1971 Value (thousand dollars)	1972 Quantity (short tons)	1972 Value (thousand dollars)	1973 Quantity (short tons)	1973 Value (thousand dollars)
Country:						
Australia	--	--	1,120	49	--	--
Canada	87,447	1,044	44,821	621	113,884	1,491
Colombia	171	(2)	--	--	--	--
Germany, West	103	1	--	--	59	1
India	37	3	--	--	--	--
Japan	--	--	20	2	--	--
Poland	--	--	--	--	12,698	115
South Africa, Republic of	11,417	434	1,127	18	--	--
Sweden	11,861	290	--	--	--	--
United Kingdom	--	--	10	1	--	--
Other	(2)	(2)	--	--	--	--
Total	111,036	1,772	47,098	691	126,641	1,607
Customs district:						
Boston	--	--	--	--	12,698	115
Buffalo	977	10	--	--	437	8
Chicago	73	(2)	--	--	403	6
Detroit	47,698	525	--	--	73,152	897
Duluth	9,584	142	16,393	246	25,076	377
Great Falls	11,844	109	7,492	61	2,143	13
Honolulu	--	--	20	2	--	--
Houston	--	--	1,120	49	--	--
New Orleans	23,278	724	1,127	18	--	--
New York City	37	3	10	1	--	--
Norfolk	--	--	--	--	12,521	188
Ogdensburg	--	--	--	--	144	2
Pembina	16,902	253	20,921	313	59	1
Portland, Maine	--	--	15	1	8	(2)
Portland, Oreg	171	(2)	--	--	--	--
San Francisco	30	(2)	(2)	(2)	--	--
Seattle	442	6	--	--	--	--
Total	111,036	1,772	47,098	691	126,641	1,607

[1] Includes slack, culm, and lignite.
[2] Less than ½ unit.

Table 49.—Bituminous coal and lignite coal: World production by country

(Thousand short tons)

Country [1]	1971	1972	1973 p
North America:			
Canada:			
Bituminous	15,132	17,427	18,010
Lignite	3,300	3,283	3,950
Greenland: Bituminous	18	4	e 5
Mexico: Bituminous	3,915	3,984	4,663
United States:			
Bituminous	545,790	584,387	577,574
Lignite	[2] 6,402	10,999	14,164
South America:			
Argentina: Bituminous	697	744	e 507
Brazil: Bituminous (marketable)	2,754	2,752	2,773
Chile: Bituminous (marketable)	1,676	1,472	1,426
Colombia: Bituminous [3]	2,756	e 3,500	e 3,600
Peru: Bituminous	101	r e 83	e 83
Venezuela: Bituminous	47	44	55
Europe:			
Albania: Lignite [4]	744	r e 843	e 952
Austria: Lignite [5]	4,156	4,139	4,005
Belgium: Bituminous	8,365	8,316	6,988
Bulgaria:			
Bituminous	251	252	246
Lignite [4]	r 29,343	29,094	29,025
Czechoslovakia:			
Bituminous	31,639	30,668	30,621
Lignite [4]	93,466	94,320	89,562
France:			
Bituminous	26,274	23,455	20,591
Lignite	3,032	3,267	3,056
Germany, East:			
Bituminous e	1,320	1,100	880
Lignite [4]	r 289,703	273,870	271,436
Germany, West:			
Bituminous	117,909	110,757	100,288
Lignite	115,167	121,712	130,797
Pech	75	--	--
Greece: Lignite	r 12,067	12,764	14,460
Hungary:			
Bituminous	r 3,659	3,309	3,759
Lignite [4]	25,886	24,439	25,761
Ireland: Bituminous	99	83	e 86
Italy:			
Bituminous	282	166	6
Lignite	1,462	952	1,429
Poland:			
Bituminous	r 160,376	166,115	172,654
Lignite [4]	38,048	42,131	43,229
Romania:			
Bituminous [6]	7,852	7,288	e 7,900
Lignite [4]	r 15,221	18,241	e 19,400
Spain:			
Bituminous	8,610	8,820	7,656
Lignite	3,396	3,369	3,304
Svalbard (Spitzbergen): Bituminous [7]	480	502	457
U.S.S.R.: [8]			
Bituminous	r 537,419	550,570	e 562,000
Lignite [4]	169,030	171,651	e 174,000
United Kingdom: Bituminous	r 157,607	128,312	140,703
Yugoslavia:			
Bituminous	779	660	636
Lignite [4]	r 33,284	33,446	35,135
Africa:			
Algeria: Bituminous [3]	r 15	13	22
Mozambique: Bituminous	r 363	370	434
Nigeria: Bituminous	r 214	376	360
Rhodesia, Southern: Bituminous [9]	r 3,408	3,045	3,373
South Africa, Republic of: Bituminous (marketable)	62,639	62,946	67,179
Swaziland: Bituminous	163	139	154
Tanzania: Bituminous	3	3	2
Zaire: Bituminous	126	141	127
Zambia: Bituminous	895	1,033	1,036
Asia:			
Afghanistan: Bituminous [10]	149	e 150	e 150
Burma: Bituminous	22	23	15
China, People's Republic of: Bituminous and lignite e	r 410,000	r 420,000	450,000
India:			
Bituminous	78,814	82,421	84,878
Lignite	4,034	3,381	3,638
Indonesia: Bituminous	218	197	164
Iran: Bituminous	r 661	1,102	1,157

See footnotes at end of table.

Table 49.—Bituminous coal and lignite coal: World production by country—Continued

(Thousand short tons)

Country [1]	1971	1972	1973 [p]
Asia—Continued			
Japan:			
Bituminous	[r] 36,852	30,966	24,709
Lignite	[r] 146	106	93
Korea, North:			
Bituminous [e]	6,600	7,200	7,700
Lignite [e]	220	220	220
Mongolia:			
Bituminous	111	117	[e] 120
Lignite	[r] 2,183	2,367	[e] 2,400
Pakistan: Bituminous and lignite [11]	[r] 1,452	1,379	1,456
Philippines: Bituminous	44	43	43
Taiwan: Bituminous	4,516	4,313	3,667
Thailand: Lignite	491	380	398
Turkey:			
Bituminous	5,114	5,116	5,118
Lignite	4,648	5,151	5,296
Oceania:			
Australia:			
Bituminous	[r] 54,015	65,748	66,914
Lignite	25,775	26,121	27,202
New Zealand:			
Bituminous	2,163	2,237	2,561
Lignite	[r] 179	168	160
World total:			
Bituminous	[r] 1,892,912	1,922,469	1,934,050
Lignite (including Pech)	[r] 881,458	886,414	903,072
Mixed grades [12]	[r] 411,452	421,379	451,456
Total, all grades	[r] 3,185,822	3,230,262	3,288,578

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition to the countries listed, Ecuador produces coal, but output was less than 500 tons annually in the years covered by this table.

[2] Excludes production from the State of Texas.

[3] May include a small amount of anthracite.

[4] Includes materials reported in natural sources as brown coal.

[5] Available sources report only lignite production; a small amount of bituminous coal may also be produced.

[6] Official sources report the aggregate of bituminous coal and anthracite; distribution to these separate grades is estimated from reported total.

[7] Output from Norwegian controlled portion only. Output of that portion of Svalbard controlled by the U.S.S.R. is presumably included in the total output recorded for that country.

[8] Run-of-mine output.

[9] Sales, for year ending August 31 of that stated.

[10] Year beginning March 21 of that stated.

[11] Year ending June 30 of that stated.

[12] Bituminous coal plus lignite for the People's Republic of China and Pakistan.

Coal—Pennsylvania Anthracite

By Dorothy R. Federoff [1]

Data in this chapter refer only to anthracite or hard coal, produced in 12 counties in northeastern Pennsylvania. The anthracite region is divided geologically into four fields: Northern, Eastern Middle, Western Middle, and Southern. The area is also grouped into three trade regions: Wyoming, Lehigh, and Schuylkill.

The production of anthracite continued to decline in 1973, but at a decelerated rate. Increased world demand for steel, shortages of metallurgical bituminous coal, and the curtailed availability of oil supplies in the last quarter of 1973 all combined to open additional markets for anthracite, creating a demand greater than the supply.

Total production of anthracite in 1973 was 6.8 million short tons, a decrease of approximately 3.9% from that of 1972. Of the total output, 48% was produced at strip pits, 35% at culm and silt banks, 11% at underground mines, and 6% at dredging operations. When compared with tonnages produced in 1972, underground production declined 23%; strip production, 6%; and dredge coal, 8%; however, culm and silt production increased 8%.

Total value of the 1973 output was $90.3 million, a 5.9% increase over that of 1972. The average value f.o.b. preparation plants for all sizes of anthracite, including dredge coal, was $13.22 per ton, compared with $12.00 per ton in 1972. The average value of pea and larger sizes increased $1.58 to $18.76 per ton, and the average value of buckwheat No. 1 and smaller sizes increased $1.16 to $11.30 per ton. Although production was less in 1973, value was greater due to the increase in prices.

Apparent consumption of Pennsylvania anthracite in the United States in 1973, calculated as production minus exports, excluding that exported to West Germany for use by the U.S. Armed Forces, totaled approximately 5.7 million tons compared with 5.9 million tons in 1972—a decrease of 4.1%. Although use data are incomplete for anthracite, slight declines occurred in all categories.

Exports of Pennsylvania anthracite, according to the U.S. Bureau of the Census, totaled 716,546 tons shipped to Canada, Europe, and other foreign countries. A more accurate measurement of exports can be obtained by adding the quantity shipped for use by the U.S. Armed Forces in West Germany to the tonnage reported by the Bureau of the Census. This computation indicates that approximately 1,159,000 tons was actually exported, or 2.7% less than in 1972.

The Pennsylvania anthracite mining industry worked an average of 234 days in 1973, compared with 216 days in the preceding year. The work force averaged 4,083 men, a drop of 14.6% below the 1972 level. Of that total, 40% were employed at strip pits, 21% at underground mines, 8% at culm and silt recovery, 1% on dredges, and 30% at breakers. Although there was a slight decline in total production and the number of men working daily, the productivity rate in average tons per man-day increased from 6.88 tons in 1972 to 7.15 tons in 1973. The rise was due primarily to an increase in surface mining. One fatality occurred in 1973 (2 in 1972), and 370 nonfatal injuries, compared with 272 in 1972.

The Bureau of Mines publishes a series of weekly reports containing estimates of weekly and monthly production based on carloadings reported by railroads, and monthly production statements of truck shipments provided by the Commonwealth of Pennsylvania.

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[1] Mineral specialist, Division of Fossil Fuels—Mineral Supply.

Table 1.—Salient statistics of the Pennsylvania anthracite industry

	1969	1970	1971	1972	1973
Production:					
Preparation plants ---------- short tons--	9,920,130	9,304,221	8,323,168	6,618,205	6,377,512
Dredges ---------- do----	535,369	409,354	389,609	476,792	441,076
Used at collieries for power and heat do----	17,417	15,823	14,548	11,298	11,373
Total production ---------- do----	10,472,916	9,729,398	8,727,325	7,106,295	6,829,961
Value ---------- thousands--	$100,770	$105,341	$103,469	$85,251	$90,260
Average sales realization per short ton on preparation plant shipments (excludes dredge coal):					
Pea and larger ----------	$13.56	$15.06	$16.39	$17.18	$18.76
Buckwheat No. 1 and smaller ----------	$7.93	$8.92	$9.90	$10.14	$11.30
All sizes ----------	$9.91	$11.03	$12.08	$12.40	$13.65
Percentage of total preparation plant shipments (excludes dredge coal):					
Pea and larger ----------	35.1	34.4	33.6	32.0	31.4
Buckwheat No. 1 and smaller ----------	64.9	65.6	66.4	68.0	68.6
Exports [1] ---------- short tons--	627,492	789,499	671,024	743,451	716,546
Consumption, apparent [2] ---------- do----	8,809,000	8,248,000	7,338,000	5,915,000	5,671,000
Average number of days worked ----------	232	234	239	216	234
Average number of men working daily -----	5,927	5,938	5,800	4,783	4,083
Output per man per day ---------- short tons--	7.45	7.10	6.30	6.88	7.15
Output per man per year ---------- do----	1,728	1,661	1,505	1,486	1,673
Quantity cut by machines ---------- do----	68,300	125,779	6,018	--	--
Quantity mined by stripping ---------- do----	4,578,732	4,541,452	4,478,350	3,483,076	3,278,977
Quantity loaded by machines underground do----	1,326,598	1,150,596	669,691	593,997	421,202
Distribution:					
Exports to Canada [1] ----------	472,763	438,008	466,039	500,306	477,692
Loaded into vessels at Lake Erie [3] ----	209,000	154,002	51,402	39,177	19,244

[1] U.S. Department of Commerce, 1968—73 export data does not include shipments to U.S. Military Forces. See NOTE, tables 4 and 25.
[2] Excludes shipments to U.S. Armed Forces.
[3] Ore and Coal Exchange, Cleveland, Ohio.

Table 2.—Standard anthracite specifications approved and adopted by the Anthracite Committee, effective July 28, 1947

Size	Round test mesh (inches)	Percent: Oversize (maximum)	Percent: Undersize Maximum	Percent: Undersize Minimum	Percent: Maximum impurities [1] Slate	Percent: Maximum impurities [1] Ash [2]	Percent: Maximum impurities [1] Bone
Broken ----------	Through 4 3/8 ----- Over 3 1/4 to 3 -----	--	--	--	1½	2	11
Egg ----------	Through 3 1/4 to 3 --- Over 2 7/16 -----	5	15	7½	1½	2	11
Stove ----------	Through 2 7/16 ----- Over 1 5/8 -----	7½	15	7½	2	3 3	11 11
Chestnut ----------	Through 1 5/5 ----- Over 13/16 -----	7½	15	7½	3	4	11
Pea ----------	Through 13/16 ----- Over 9/16 -----	10	15	7½	4	5	12
Buckwheat No. 1 ----------	Through 9/16 ----- Over 5/16 -----	10	15	7½	--	--	13
Buckwheat No. 2 (rice) --	Through 5/16 ----- Over 3/16 -----	10	15	7½	--	--	13
Buckwheat No. 3 (barley)	Through 3/16 ----- Over 3/32 -----	10	17	7½	--	--	15
Buckwheat No. 4 ----------	Through 3/32 ----- Over 3/64 -----	20	20	10	--	--	15
Buckwheat No. 5 ----------	Through 3/64 -----	30	30 No limit	10	--	--	16

[1] When slate content in sizes from broken to chestnut, inclusive, is less than the above standards, bone content may be increased by 1½ times the decrease in slate content under the allowable limits, but slate content specified above shall not be exceeded in any event.
A tolerance of 1% is allowed on maximum percentage of undersize and maximum percentage of ash content.
Maximum percentage of undersize is applicable only to anthracite as it is produced at preparation plants.
Slate is defined as any material that has less than 40% fixed carbon.
Bone is defined as any material that has 40% or more, but less than 75%, fixed carbon.
[2] Ash determinations are on a dry basis.

Legislation and Government Programs.— Federal and State government programs in the environmental area continued through 1973, and included control and extinguishment of fires at abandoned underground and surface mines, prevention of surface subsidence above abandoned mines, reclamation of old strip pits and culm banks, and mine-water control projects designed to secure the safety and livelihood of mine personnel and to protect anthracite reserves from the hazards of adjoining abandoned mine pools and possible inundation by surface floodwaters.

Hydrologic studies to evaluate mine-water problems were continued. They involved determination of the varying heights of underground mine pools, their hydrostatic pressures and possible effect upon barrier pillars and mine dams protecting active mining operations, acid mine-water drainage into surface streams, and the unconsolidated valley fill. A comprehensive series of mine pool monitoring stations has been installed in the Western Middle and Southern Fields. The time available for project work particularly in map work related to subsidence, mine-water, and levee studies, was severely limited because of additional assignments resulting from the flood in 1972.

Table 3.—Project report

Project location	Project description	Sponsor	Status of report
	ACID COAL MINE DRAINAGE		
Anthracite fields	Monthly measurements of mine water levels and overflows.	U.S. Geological Survey.	Continuous.
Lackawanna County:			
Jermyn Borough	Stream pollution abatement	Commonwealth of Pennsylvania.	Work in progress 1973.
	SURFACE SUBSIDENCE		
Lackawanna County:			
Scranton, Green Ridge.	Demonstration project for fill of mine voids under approximately 35 acres of Green Ridge section of Scranton.	Commonwealth of Pennsylvania and U.S. Bureau of Mines.	Work started 1972. Still in progress.
Scranton, Minooka section.	Filling mine voids. Blind flushing approximately 17 acres of area. Pilot demonstration project.	do	Work in progress 1973.
Scranton, Southside section.	Hydraulic flushing of mine voids, Project 11.	do	Do.
Scranton, Hill section.	Filling abandoned mine voids	do	Do.
Carbondale	Appalachian subsidence control, Project 8.	do	Do.
Luzerne County:			
City of Wilkes-Barre, Parsons section.	Appalachian subsidence control, Project 14.	do	Work started in 1973; project completed.
	UNDERGROUND MINE FIRES		
Columbia County:			
Centralia Borough	Appalachia mine fire control, which includes Phase I exploratory drilling, Phase II (1) underground barrier pillars formed by injecting fly ash into mine void of west barrier, and Phase II (2) underground barrier pillars formed by injecting fly ash into mine void east barrier.	Commonwealth of Pennsylvania and U.S. Bureau of Mines.	Work in progress 1973.
Luzerne County:			
Hazleton Borough	Appalachia mine fire control at site of former Hill mine property, which includes Phase I exploratory drilling and Phase II seal blocking with sand and total fire excavation.	do	Phase I completed 1969; Phase II work in progress 1972. Completed in 1973.

Table 3.—Project report—Continued

Project location	Project description	Sponsor	Status of report
UNDERGROUND MINE FIRES—Continued			
Luzerne County—Continued			
Laurel Run Borough	Appalachia mine fire control, which included Phase I exploratory activities, Phase II (1) sealing three tunnels, Phase II (2) reinforcing East and West barriers with sand seals, and Phase II (3) additional sand barrier seals.	Commonwealth of Pennsylvania and U.S. Bureau of Mines.	All phases completed 1973.
Swoyersville Borough	Appalachia mine fire control at site of former Forty Fort Mine property, which includes Phase I exploratory drilling and Phase II excavation.	----do----------	Completed in 1973.
Warrior Run Borough.	Appalachia mine fire control at site, which includes exploratory drilling to determine extent of fire.	----do----------	Work started in 1971. Still in progress 1973.
Schuylkill County:			
Shenandoah Borough	Appalachia mine fire control at site of former Kehley Run colliery, Phase I exploratory drilling only; control work taken over by Commonwealth of Pennsylvania in 1970.	----do----------	Completed in 1973.
SURFACE MINE RECLAMATION PROJECTS			
Lackawanna County:			
Taylor Borough ----	Keyser Valley strip mine area reclamation demonstration project.	Commonwealth of Pennsylvania and U.S. Bureau of Mines.	Part I started 1972, completed 1973. Part II started and completed, 1973.
Luzerne County:			
Preston -----------	Conservation and Development—Refuse bank reclamation demonstration project.	----do----------	Started 1973, still in progress.

The development of new technology to backfill underground mine voids to prevent subsidence was demonstrated successfully. The work consisted of drilling exploratory boreholes, sonar caliper surveying of mine beds, receiving crushed culm or breaker material from a mixer-blender plant, and flushing the material as a water slurry through the boreholes into the inundated and dry mine voids of the demonstration mines. When the project is completed, the boreholes are then pulled and sealed with concrete.

An overall program aimed at controlling fires in anthracite and other coal refuse banks included investigations into the cause and environmental effects of these fires, attempts at their early detection and inventorying, and the development of economic techniques for quenching and removing burning coal refuse banks. Two demonstration projects have been completed—one evaluating the most effective use of relatively conventional means of extinguishment, and the other involving a technique of simultaneously quenching burning material by surface sprinklers and a subsurface water injection system. Work was judged successful in terms of the amount of water utilized in extinguishment and material removed. Under the two phases of the project, a total of 390,000 cubic yards of bank material was quenched, excavated, and leveled.

The value of the longstanding map folio program to the public was demonstrated by the numerous requests received by the Bureau of Mines from various local authorities to evaluate subsurface conditions in relation to subsidence potential for proposed civic improvements and investigations of possible structural failure in bridges and highways. The data accumulated by the program have also proved an invaluable aid in evaluations made by the U.S. Army Corps of Engineers for the maintenance, and possible expansion, of flood control projects under its jurisdiction in the Northern anthracite field.

In a continuation of the project to record the maps of underground workings at anthracite mines, maps of a total of 301 major and 20 independent mines located in the 4 anthracite fields have been photographed. Work continued on compiling surface and bed maps in stratigraphic sequence for selected areas in the Northern field.

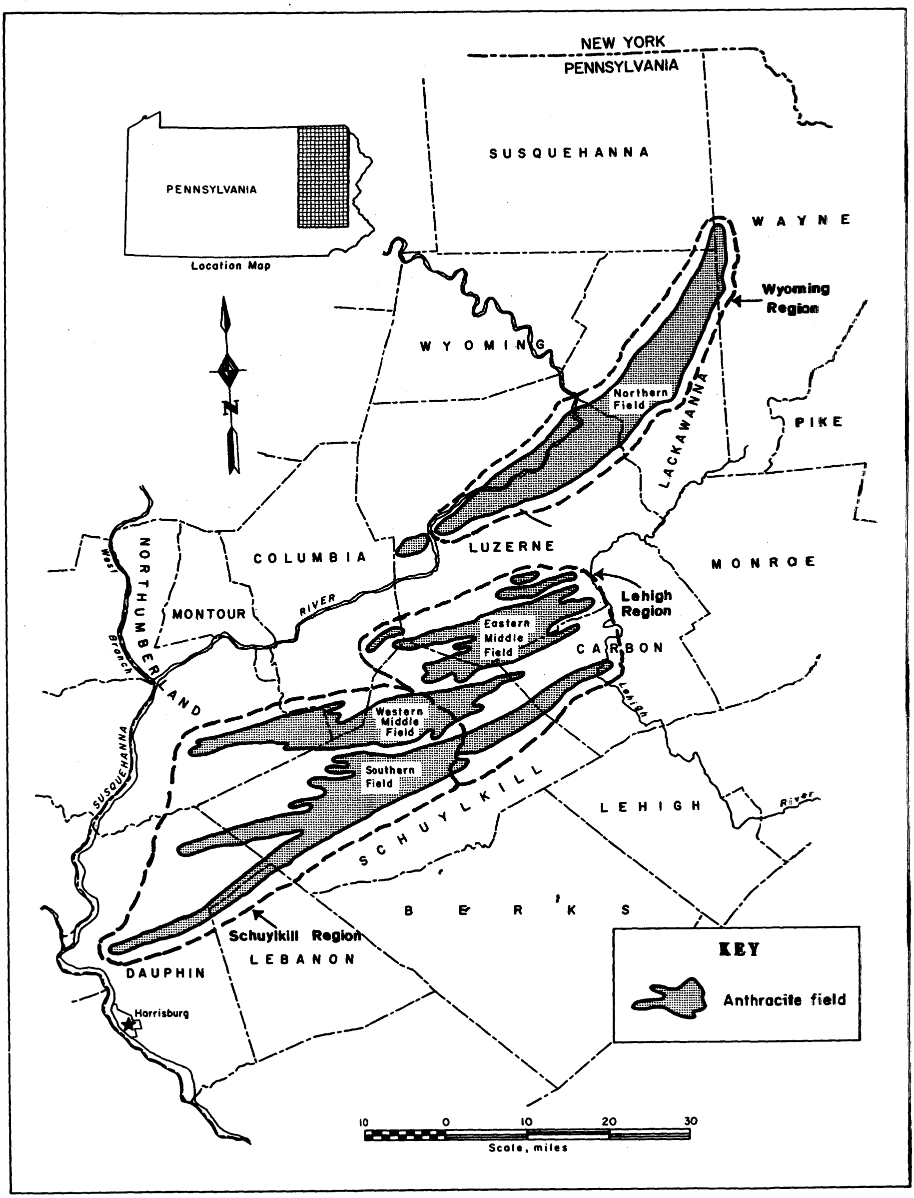

Figure 1.—Coalfields, regions, and counties of the Pennsylvania anthracite area.

DOMESTIC PRODUCTION

Production of Pennsylvania anthracite totaled 6.8 million short tons in 1973, a decrease of approximately 3.9% from that of 1972. Underground production accounted for 11% of the total output, compared with 13% in 1972. The decline in underground mining was due to health and safety consideration, manpower shortages, and the high cost of pumping water from flooded mines. Strip production totaled 48% (49% in 1972); culm and silt recovery, 35% (31% in 1972); and river coal, 6% (7% in 1972).

Two of the producing regions showed losses in 1973. In the Schuylkill region, total production was 0.8% less than that in 1972, and the total production in the Wyoming region showed a decrease of 24%. However, production in the Lehigh region indicated a slight gain of 5% over that in 1972. The Schuylkill region contributed 59% of the total production; the Lehigh region, 26%; and the Wyoming region, 15%.

The two leading counties in the production of anthracite were Schuylkill County with a total of 3 million tons, and Luzerne County with approximately 2 million tons. Other counties producing anthracite were Berks, Carbon, Columbia, Dauphin, Lackawanna, Lancaster, Northumberland, Snyder, Sullivan, and Susquehanna.

In operation at strip pits and in culm recovery were 138 front-end loaders, 50 power shovels, and 112 draglines.

Underground production in 1973 totaled 725,789 tons, a decrease of 23% from that in 1972. The Schuylkill region accounted for 77% of the output, and the Wyoming region for the remainder. Output in the Schuylkill region decreased by approximately 13%; the Wyoming region output dropped 44%.

Of the total underground anthracite produced, 58% was loaded mechanically, compared with approximately 63% in 1972. The mechanical loading of anthracite declined 29% from the level of 1972, with a concurrent decrease of approximately 14% in the number of loading units. The total mechanical equipment consisted of 72 scraper loaders, 4 mobile loaders, and 47 conveyor and pit-car loaders.

Production from strip mines totaled approximately 3.3 million tons, a decrease of 5.9% from that of 1972, and accounted for 48% of the total production in 1973. Output in the Schuylkill region totaled 1.4 million tons, a decrease of 7.4%; and in the Wyoming region, approximately 683,000 net tons, a decrease of 20.6%. However, the Lehigh region, with approximately 1.2 million tons, indicated an increase of 8.1% over that in 1972.

Culm and silt recovery totaled 2.4 million tons, an increase of approximately 182,000 tons, or 8% above the 1972 output. The Schuylkill region indicated a slight increase, 68% of the total recovered in 1973, compared with 64% in 1972. However, the percent of recovery decreased in the Lehigh region, to 26% compared with 28% in 1972; and in the Wyoming region, to 7% compared with 8% in 1972.

Dredging operations produced approximately 441,000 tons in 1973, a decrease of 8% from that in 1972, and a significant drop from the 1.5 million tons recovered in 1941. In the preceding decades, many dredges worked the rich coal deposits on the river beds; a significant portion was consumed in the generating of electricity. After 50 years of river dredging, the Pennsylvania Power and Light Co. will discontinue their river mining because of insufficient coal remaining on the riverbed to make the salvage operation economically feasible.

DISTRIBUTION

Shipments of Pennsylvania anthracite reported for the calendar year January 1, 1973, to December 31, 1973, totaled 6,341,928 net tons, a decrease of approximately 5.8% from the 1972 calendar year. Of this amount, 81.7% was shipped to markets within the United States (a decrease of 6.5%), 7.5% was exported to Canada (a decrease of 1.4%), and 10.8% was exported to countries other than Canada (a decrease of 1.4% from 1972).

In the U.S. market, shipments of pea and larger sizes decreased by 4.2%, and buckwheat No. 1 and smaller decreased by 7.5%. In the Canadian market, the pea and larger sizes dropped 36.3%, while the total buckwheat No. 1 and smaller sizes increased by 5.5%. Exports to countries other than Canada indicated an increase of 3.3% in the pea and larger sizes, but a decline of 8.6% in the buckwheat No. 1 and smaller sizes.

All market areas in the United States indicated losses, except the South Atlantic and the Lake States, which showed increases of 91.7% and 17.5%, respectively. In 1973, shipments to West Virginia were included in the South Atlantic States instead of the "Other States" category as they were in 1972, which accounts for the greater percentage increase in that area. Shipments to the New England States and the Middle Atlantic States decreased by 2.5% and 9.3%, respectively.

CONSUMPTION AND USES

Apparent consumption of Pennsylvania anthracite in the United States in 1973, calculated as production minus exports, including shipments to the U.S. Armed Forces in West Germany, totaled 5.6 million tons, compared with 5.9 million tons in 1972. Of the total anthracite consumed, 51% was used for space heating, 25% by the electric utilities, and 13% by the iron and steel industry; the remaining 11% was distributed among cement plants, colliery fuel, and other uses.

Although use data are incomplete, all categories indicated slight declines in the consumption of anthracite. The declining market for anthracite in space heating and electric utilities is attributable to the conversion from anthracite to the more convenient and less costly fuels. However, due to the curtailed availability, and the rising cost of oil and gas in the near future, the decline in the space-heating market for anthracite may decelerate.

The Federal Government continued to supplement the fuel needs of the U.S. Armed Forces in West Germany with purchases of anthracite. Shipments in 1973 were approximately 443,000 net tons, compared with 448,000 tons in 1972, a 1% decrease.

STOCKS

The electric utilities reported an increase in their inventory of 171,000 short tons of anthracite to 1,066,000 tons at yearend 1973, compared with 895,000 tons at yearend 1972, an increase of 19.1%

Stocks at coke plants totaled 97,000 tons at yearend 1973, compared with 84,000 tons at yearend 1972, an increase of 15.5%.

Monthly data on stocks held in retail yards indicated an inventory of 106,000 tons at yearend 1973, a decrease of 13.9% from yearend 1972.

Stocks at Upper Lake docks (Lake Superior and Lake Michigan) comprised less than 500 tons at yearend 1973, relatively comparable to yearend 1972.

PRICES AND SPECIFICATIONS

Based on total production, including colliery fuel and dredge coal, the average value of Pennsylvania anthracite for 1973 was $13.22 per ton, compared with $12.00 per ton in 1972. Total value of production was approximately $90.3 million, an increase of 6% over that in 1972. Although production had declined, the value was greater than in 1972 because of increases in the price of coal. Anthracite producers increased prices on all sizes during the year to compensate for additional taxes to cover black lung benefits, increased workmen's compensation taxes, and higher costs of mining.

The average value per ton of the larger sized groups was $18.76 f.o.b. preparation plants, an increase of $1.58. The price increase per ton for the larger sizes was egg, $1.44, stove, $1.78, chestnut, $1.64, and pea, $1.26. The average value per ton of the smaller sizes increased by $1.16, to $11.30 per ton. The individual prices of the smaller sizes were as follows: Buckwheat No. 1, $16.60 (an increase of $1.22); buckwheat No. 2 (rice), $16.77 (an increase of $1.65); buckwheat No. 3 (barley), $14.11 (an increase of $1.14); buckwheat No. 4, $10.78 (an increase of $1.67); buckwheat No. 5, $8.39 (an increase of $2.36); and other, $5.78 (an increase of $0.63). All of these prices exclude dredge coal.

Average wholesale prices as quoted in the Black Diamond magazine f.o.b. preparation plants were as follows: Egg and stove, $19.75 to $23.50; chestnut, $19.50 to $22.50; pea, $17.50 to $19.60; buckwheat No. 1, $17.50 to $19.60; buckwheat No. 2 (rice), $17.50 to $19.60; and buckwheat No. 3 (barley), $16.50 to $18.50.

FOREIGN TRADE

According to the data released by the Bureau of the Census, U.S. Department of Commerce, 716,546 tons of Pennsylvania anthracite were exported in 1973, a decrease of approximately 4% from that exported in 1972. Of the total, 67% was shipped to Canada (5% less than in 1972), 26% to Europe, 5% to South America, and the remainder to other countries. However, this does not fully reflect the total shipments to Europe because the Bureau of the Census does not include in its figures coal shipped abroad for use by the U.S. Armed Forces in West Germany. A more accurate measure of the export trade can be obtained by adding the military tonnage (442,699 net tons) to the Bureau of the Census data. Consequently, 1,159,000 net tons of anthracite were exported in 1973.

WORLD REVIEW

World production in 1973 totaled 191.9 million short tons, compared with 192.6 million tons in 1972. The combined production of the U.S.S.R., the People's Republic of China (PRC), and North Korea totaled approximately 138.3 million tons, or 72% of the total.

Anthracite imports by Japan totaled 1,057,675 short tons in an 11-month period (January–November) of 1973, and represented an increase of 41.6% over imports in the same period in 1972. The PRC supplied 319,471 tons, or 30.2% of the total. The Republic of Korea increased its exports to Japan by 231,767 tons for the same period, and shipments of 154,611 tons of anthracite from the Republic of South Africa was an 84.8% increase over the same period in 1972. Imports from Canada decreased slightly for the January–November period; 112,749 short tons were shipped in 1973, compared with 118,233 tons in 1972.

Exports from North Vietnam to Japan increased significantly after the shipping blockade was lifted in August. Since shipments resumed, Japan has purchased approximately 190,000 tons of Honggai anthracite, compared with 74,000 tons in 1972. A group of Japanese companies has negotiated a contract with North Vietnam for the purchase of 500,000 to 700,000 tons of anthracite for 1975.

Anthracite continued to be the Republic of Korea's most valuable mineral, representing 70% of the total value of minerals produced. Despite the heavy storm that flooded several major coal mines in August 1972, production totaled 13.7 million tons, and increased to approximately 15.0 million tons in 1973.

The Republic of South Africa showed an increase in the production of anthracite to 1.6 million short tons in 1973, compared with 1.5 million tons in 1972. Exports increased by 135,982 tons, totaling 998,114 tons. Prices registered increases of 14.6% for domestic sales and 9.3% for exports.

The U.S.S.R. production of anthracite in 1973 was approximately 83.2 million tons, a slight increase over that in 1972. Exports totaled approximately 4.8 million tons. The major markets for Soviet coal are Japan, Italy, France, and Austria. Most coal exports are shipped under relatively long-term trade agreements and usually vary slightly from the agreed tonnages reported.

France produced approximately 7.7 million tons of anthracite in 1973, a decline of 17.7% from that in 1972. Of the total anthracite imported (2.8 million tons), the Soviet Union supplied 33%; the Federal Republic of Germany, 23%; the Republic of South Africa, 14%; and the Netherlands, 12%. The United States and the United Kingdom completed the list of the more significant suppliers.

During the first 6 months of 1973, Yugoslavia's imports of solid fuels increased slightly from the corresponding period of 1972. Anthracite imports increased from 83,057 tons in 1972 to 96,717 tons in 1973, and accounted for 16.5% of the solid fuels imported.

Anthracite production for the United Kingdom and West Germany, decreased by 19% and 20%, respectively in 1973.

As Italy has insignificant coal resources of its own, it is almost entirely dependent on imports for its coal requirements. The Soviet Union, the United States, and France supplied Italy with anthracite in 1973.

TECHNOLOGY

The use of anthracite as a molecular sieve was investigated. Several coal gasification processes now under development require a supply of oxygen. If air is used for gasification, not only is the product gas of lower calorific value because of dilution with nitrogen, but also the volume of gas to be cleaned of sulfur is much larger, and therefore, the cleaning is more expensive. Studies at Pennsylvania State University indicated that anthracite has the possibility of making a cheaper separation of oxygen and nitrogen, as well as other important industrial gases.[2] Anthracites, as they occur naturally, have a large volume within their pore structures, but the pore entrances are so small that few gases can enter, and those only slowly. However, if a small part of the anthracite is gasified, the pore entrances can be enlarged in a controlled manner. In several anthracite samples, 6.9%, 8.0%, and 9.1% of carbon was gasified by heating each sample in air to 425° C, and then in nitrogen to 950° C.

This small difference in amount gasified was enough to make a large difference in the rate at which methane could enter the porous structure. For carbon dioxide the amount that could enter and be absorbed within the 9.1% sample was only 1.6 times the amount within the 6.9% sample. For the hydrocarbon neopentane, which has a larger molecule than carbon dioxide, the amount that could be adsorbed under the same conditions increased by a factor of 100.

The results demonstrate that the production of effective molecular sieves from anthracites is feasible. They also show that the fine control over pore entrance sizes that is provided by slight gasification gives a means of tailormaking molecular sieves to perform a variety of important separations.

Consumption of anthracite for molecular sieve production would obviously be less than consumption of coal for direct fuel uses, but it would be enough to make a significant contribution to the total utilization of anthracite resources.

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[2] Pennsylvania State University, Coal Research Section. Preparation of Molecular Sieve Materials From Anthracite. Res. and Devel. Rept. 61, Interim Rept. 6, Mar. 15, 1973, pp. 1–2.

Table 4.—Summary of monthly developments in the Pennsylvania anthracite industry in 1973

(Thousand short tons, except as otherwise indicated)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total 1973	Change from 1972 (percent)	Total 1972
Production (including mine fuel, local sales, and dredge coal)	522	568	641	581	641	609	434	587	532	614	582	519	6,830	— 3.9	7,106
Shipments (breakers and washeries only, all sizes):															
By rail [1]	146	182	285	270	309	350	258	317	268	317	252	179	3,133	+12.1	2,795
By truck [2]	367	379	310	267	314	267	226	323	292	360	380	286	3,771	— 4.9	3,966
Carloadings [3]	2	3	6	4	6	6	4	5	4	5	4	3	52	+ 6.1	49
Distribution:															
Lake Erie loadings [4]	--	--	--	--	--	4	--	5	6	2	2	--	19	—51.3	39
Upper Lake dock trade: [5]															
Receipts	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	1	--	1
Deliveries (reloadings)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	1	—50.0	2
Exports [7]	40	5	93	58	91	72	33	95	37	97	47	48	716	— 3.6	743
Industrial consumption and stocks by—															
Electric utilities: [8]															
Consumption	126	101	116	100	126	135	128	138	111	122	125	114	1,442	— 9.0	1,584
Stocks	852	841	866	915	897	939	960	1,026	1,053	1,080	1,087	1,066	1,066	+19.1	895
Coke plants:															
Used for carbonizing	45	38	42	36	37	41	36	38	36	34	43	41	467	— 1.5	474
Stocks	70	54	41	40	48	50	53	56	61	72	97	97	97	+15.5	84
Stocks on Upper Lake docks: [5]															
Lake Superior	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lake Michigan	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	--	(6)
Stocks in retail dealer yards: [9]															
Chestnut and larger	67	57	58	60	69	76	78	85	82	74	63	65	65	—11.0	73
Pea	7	5	6	7	7	8	9	10	9	9	10	7	7	--	7
Buckwheat No. 1 and rice	37	30	34	37	37	40	34	32	32	36	34	31	31	—27.9	43
Total	111	92	98	104	113	124	121	127	123	119	107	106	106	—13.8	123
Retail dealer deliveries: [9]															
Chestnut and larger	63	55	31	20	14	13	12	21	33	45	61	62	430	—27.2	591
Pea	22	21	15	18	18	10	10	22	18	32	39	33	258	+43.3	180
Buckwheat No. 1 and rice	50	48	37	31	26	31	18	40	23	23	30	31	388	— 3.2	401
Total	135	124	83	69	58	54	40	83	74	100	130	126	1,076	— 8.2	1,172

Wholesale price indexes (1957–59 = 100):[10]															
F.o.b. car at mines:															
Chestnut	146.1	146.1	146.1	149.8	149.8	149.8	151.7	156.4	158.3	158.3	161.1	165.3	153.2	+10.3	r 138.9
Buckwheat No. 1	176.5	176.5	176.5	181.6	181.6	181.6	181.6	189.2	191.7	191.7	193.9	197.0	185.0	+10.7	r 167.1

r Revised.
1 Furnished by initial carriers.
2 Pennsylvania Department of Mines and Mineral Industries.
3 Association of American Railroads.
4 Ore and Coal Exchange, Cleveland, Ohio.
5 Data furnished by Lake dock operators.
6 Less than ½ unit.
7 U.S. Department of Commerce. Does not include shipments to the U.S. military forces.
8 Federal Power Commission.
9 Estimated from reports submitted by a selected list of retail dealers located outside the producing region.
10 Furnished by the Bureau of Labor Statistics from data obtained from authorized trade publications.

NOTE:—According to the Association of American Railroads, 659,516 short tons of anthracite were exported to Europe during 1973 compared with 697,092 short tons for 1972. Of this total 436,507 short tons were consigned to West Germany and the Netherlands, including exports to the U.S. military forces. This compares with 464,680 short tons for 1972.

Table 5.—Commercial production of Pennsylvania anthracite in 1973, by region and size

Size	From preparation plants												From river dredging			Total [2]		
	Lehigh region			Schuylkill region			Wyoming region [1]			Total preparation plants [2]								
	Rail	Truck	Total [2]	Rail	Truck	Total [2]	Rail	Truck	Total [2]	Rail	Truck	Total	Rail	Truck	Total [2]	Rail	Truck	Total
Quantity, thousand short tons:																		
Lump and broken	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Egg	79	2	81	8	3	11	20	1	21	107	6	113	--	--	--	107	6	113
Stove	198	31	229	200	129	329	109	33	142	507	193	701	--	--	--	507	193	701
Chestnut	79	96	175	121	216	337	28	111	139	228	424	652	--	--	--	228	424	652
Pea	54	96	150	52	192	244	14	132	146	119	420	540	--	--	--	119	420	540
Total pea and larger [2]	410	225	635	381	541	922	170	278	448	961	1,044	2,005	--	--	--	961	1,044	2,005
Buckwheat No. 1	121	79	200	100	214	314	14	146	160	235	440	674	--	--	--	235	440	674
Buckwheat No. 2 (rice)	17	143	160	31	265	296	2	90	92	50	498	549	--	--	--	50	498	549
Buckwheat No. 3 (barley)	89	77	166	127	276	404	21	111	132	237	465	701	--	--	--	237	465	701
Buckwheat No. 4	67	33	100	222	85	307	27	28	55	316	145	461	--	7	7	316	152	468
Buckwheat No. 5	182	74	256	509	223	732	26	1	27	717	299	1,015	2	113	115	719	412	1,131
Other [3]	--	253	253	93	530	623	26	69	95	120	851	971	312	6	318	432	857	1,290
Total buckwheat No. 1 and smaller [2]	476	659	1,135	1,083	1,593	2,677	115	445	561	1,675	2,698	4,373	314	127	441	1,989	2,824	4,813
Grand total [2]	886	884	1,770	1,464	2,134	3,599	286	723	1,009	2,636	3,741	6,378	314	127	441	2,951	3,868	6,819
Value, thousands:																		
Lump and broken	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Egg	$1,568	$44	$1,612	$133	$55	$188	$391	$16	$408	$2,093	$114	$2,207	--	--	--	$2,093	$114	$2,207
Stove	3,820	614	4,435	3,846	2,527	6,373	2,197	668	2,865	9,863	3,810	13,673	--	--	--	9,863	3,810	13,673
Chestnut	1,469	1,881	3,350	2,267	4,129	6,396	561	2,268	2,829	4,296	8,279	12,575	--	--	--	4,296	8,279	12,575
Pea	879	1,570	2,449	875	3,237	4,113	240	2,360	2,600	1,994	7,167	9,161	--	--	--	1,994	7,167	9,161
Total pea and larger [2]	7,736	4,109	11,845	7,121	9,949	17,070	3,389	5,312	8,702	18,246	19,370	37,617	--	--	--	18,246	19,370	37,617
Buckwheat No. 1	2,042	1,338	3,381	1,564	3,466	5,030	239	2,547	2,787	3,846	7,352	11,198	--	--	--	3,846	7,352	11,198
Buckwheat No. 2 (rice)	297	2,406	2,703	508	4,337	4,845	35	1,617	1,653	841	8,360	9,201	--	--	--	841	8,360	9,201
Buckwheat No. 3 (barley)	1,356	1,130	2,486	1,723	3,853	5,576	289	1,547	1,836	3,368	6,530	9,898	--	--	--	3,368	6,530	9,898
Buckwheat No. 4	738	327	1,064	2,667	672	3,339	292	275	567	3,696	1,274	4,970	--	28	28	3,696	1,302	4,998
Buckwheat No. 5	1,535	641	2,176	4,311	1,796	6,108	231	9	240	6,076	2,447	8,523	9	453	461	6,085	2,900	8,984
Other [3]	--	1,295	1,295	438	3,194	3,632	167	517	684	605	5,006	5,611	2,551	29	2,580	3,156	5,035	8,191
Total buckwheat No. 1 and smaller [2]	5,968	7,137	13,105	11,211	17,319	28,530	1,253	6,513	7,766	18,433	30,969	49,401	2,560	510	3,070	20,992	31,479	52,471
Grand total [2]	13,704	11,246	24,951	18,332	27,268	45,600	4,643	11,825	16,468	36,679	50,339	87,018	2,560	510	3,070	39,239	50,849	90,088

Average value per ton:[4]																		
Lump and broken	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Egg	$19.78	$19.41	$19.77	$17.14	$17.77	$17.32	$19.98	$19.84	$19.88	$19.61	$18.65	$19.55	--	--	--	$19.61	$18.65	$19.55
Stove	19.30	19.86	19.37	19.21	19.56	19.35	20.11	20.00	20.08	19.44	19.69	19.51	--	--	--	19.44	19.69	19.51
Chestnut	18.64	19.49	19.11	18.71	19.09	18.96	20.21	20.40	20.36	18.87	20.59	19.30	--	--	--	18.87	20.59	19.30
Pea	16.25	16.42	16.36	16.95	16.83	16.86	17.64	17.84	17.82	16.71	17.06	16.98	--	--	--	16.71	17.06	16.98
Total pea and larger	18.86	18.24	18.64	18.70	18.39	18.52	19.90	19.13	19.42	18.99	18.56	18.76	--	--	--	18.99	18.56	18.76
Buckwheat No. 1	16.87	16.87	16.87	15.62	16.17	16.00	17.50	17.46	17.46	16.38	16.73	16.60	--	--	--	16.38	16.73	16.60
Buckwheat No. 2 (rice)	17.12	16.86	16.89	16.33	16.34	16.34	18.15	17.93	17.93	16.68	16.78	16.77	--	--	--	16.68	16.78	16.77
Buckwheat No. 3 (barley)	15.26	14.68	14.99	13.54	13.95	13.82	14.07	13.88	13.91	14.23	14.06	14.11	--	--	--	14.23	14.06	14.11
Buckwheat No. 4	10.99	10.03	10.68	12.00	7.93	10.87	10.82	10.00	10.40	11.69	8.80	10.78	--	4.03	4.03	11.69	8.58	10.68
Buckwheat No. 5	8.45	8.60	8.49	8.47	8.06	8.34	9.02	7.74	8.96	8.49	8.19	8.39	4.00	4.00	4.00	8.47	7.04	7.95
Other[3]	--	5.13	5.13	4.69	6.03	5.83	6.31	7.48	7.15	5.05	5.88	5.78	8.17	4.50	8.10	7.30	5.87	6.35
Total buckwheat No. 1 and smaller	12.54	10.83	11.55	10.35	10.87	10.66	10.88	14.62	13.85	11.01	11.49	11.30	8.14	4.03	6.96	10.55	11.15	10.90
Grand total	15.46	12.72	14.10	12.52	12.78	12.67	16.26	16.35	16.33	13.92	13.45	13.65	8.14	4.03	6.96	13.30	13.15	13.22

[1] Includes Sullivan County.
[2] Data may not add to totals shown because of independent rounding.
[3] Includes various mixtures of buckwheat Nos. 2 to 5 and coal of relatively low dollar value.
[4] Average value derived from actual, rather than rounded, data.

Table 6.—Sizes of Pennsylvania anthracite (excluding dredge coal) prepared at plants, by region

(Percent)

Size	1969	1970	1971	1972	1973	1969	1970	1971	1972	1973
	Lehigh region					Schuylkill region				
Lump [1] and broken	--	--	--	--	--	--	--	--	--	--
Egg	4.6	4.0	4.6	2.4	4.6	1.2	1.0	0.9	0.3	0.3
Stove	10.0	9.4	10.9	10.8	12.9	9.8	10.7	10.4	10.2	9.1
Chestnut	13.1	11.1	11.0	10.6	9.9	11.3	12.3	10.7	10.1	9.4
Pea	12.2	11.5	12.7	12.9	14.4	7.4	8.3	7.4	6.9	6.8
Total pea and larger	38.4	33.7	36.4	32.3	35.9	29.7	32.3	29.4	27.5	25.6
Buckwheat No. 1	11.7	10.2	10.6	12.1	11.3	11.2	11.0	10.2	9.0	8.7
Buckwheat No. 2 (rice)	11.2	9.4	10.7	9.0	9.0	9.2	9.8	8.9	8.8	8.3
Buckwheat No. 3 (barley)	10.8	11.9	10.1	9.1	9.4	14.5	13.1	12.7	12.2	11.2
Buckwheat No. 4	8.0	7.2	5.6	5.9	5.6	7.0	6.8	9.6	10.3	8.5
Buckwheat No. 5	16.9	14.7	12.1	14.5	14.5	13.2	13.5	20.4	22.0	20.4
Other [2]	3.0	12.9	14.5	17.1	14.3	15.2	13.5	8.8	10.2	17.3
Total buckwheat No. 1 and smaller	61.6	66.3	63.6	67.7	64.1	70.3	67.7	70.6	72.5	74.4
	Wyoming region					Total				
Lump [1] and broken	--	--	(3)	--	--	--	--	(3)	--	--
Egg	3.1	2.4	1.9	1.7	2.1	2.5	2.1	2.1	1.1	1.7
Stove	12.0	10.3	13.0	13.6	14.1	10.4	10.3	11.1	11.0	11.0
Chestnut	15.9	15.5	12.7	15.6	13.8	12.8	12.7	11.2	11.4	10.2
Pea	12.2	11.5	12.7	12.9	14.4	9.4	9.3	9.2	8.5	8.5
Total pea and larger	43.2	39.7	40.3	43.8	44.4	35.1	34.4	33.6	32.0	31.4
Buckwheat No. 1	14.7	15.4	17.1	16.4	15.9	12.2	11.8	11.8	11.2	10.7
Buckwheat No. 2 (rice)	9.4	8.7	8.8	9.8	9.1	9.7	9.4	9.3	9.1	8.6
Buckwheat No. 3 (barley)	9.7	10.7	11.0	11.5	13.1	12.4	12.2	11.6	11.3	11.0
Buckwheat No. 4	3.6	5.3	4.3	4.4	5.4	6.4	6.6	7.4	8.0	7.2
Buckwheat No. 5	2.6	4.5	3.4	2.5	2.7	11.6	11.8	14.6	16.1	15.9
Other [2]	16.8	15.7	15.1	11.6	9.4	12.6	13.8	11.7	12.3	15.2
Total buckwheat No. 1 and smaller	56.8	60.3	59.7	56.2	55.6	64.9	65.6	66.4	68.0	68.6

[1] Quantity of lump included is insignificant.
[2] Includes various mixtures of buckwheat Nos. 2 to 5 and coal of relatively low dollar value.
[3] Less than 0.05%.

Table 7.—Production of Pennsylvania anthracite in 1973, by region and county

(Thousand short tons and thousand dollars)

Source	Rail shipments		Truck shipments		Colliery fuel		Total production [1]	
	Quantity	Value [2]	Quantity	Value [2]	Quantity	Value	Quantity	Value [2]
REGIONS								
Lehigh:								
Preparation plants	886	13,704	884	11,246	2	40	1,773	24,991
Schuylkill:								
Preparation plants	1,464	18,332	2,134	27,268	6	84	3,605	45,684
Dredges	314	2,560	127	510	--	--	441	3,070
Total Schuylkill [1]	1,779	20,892	2,261	27,778	6	84	4,046	48,754
Wyoming:								
Preparation plants [3]	286	4,643	723	11,825	3	47	1,011	16,515
Total: [1]								
Preparation plants	2,636	36,679	3,741	50,339	11	172	6,389	87,190
Dredges	314	2,560	127	510	--	--	441	3,070
Grand total [1]	2,951	39,239	3,868	50,849	11	172	6,830	90,260
COUNTIES								
Berks, Lancaster, Snyder	314	2,560	127	510	--	--	441	3,070
Carbon	98	1,545	18	76	--	--	116	1,621
Columbia	5	78	7	106	--	--	12	184
Dauphin	1	8	38	501	(4)	1	40	510
Lackawanna	110	1,876	123	1,917	(4)	2	232	3,795
Luzerne	760	12,133	1,218	17,449	5	82	1,982	29,663
Northumberland	412	4,660	546	7,265	1	16	959	11,940
Schuylkill	1,250	16,379	1,747	22,630	5	72	3,003	39,081
Sullivan	--	--	41	381	--	--	41	381
Susquehanna	--	--	4	15	--	--	4	15
Total [1]	2,951	39,239	3,868	50,849	11	172	6,830	90,260

[1] Data may not add to totals shown because of independent rounding.
[2] Value given for shipments is that at which coal left possession of producing company; does not include selling expenses.
[3] Includes Sullivan County.
[4] Less than 1,000 short tons.

Table 8.—Pennsylvania anthracite produced, by field

(Thousand short tons)

Field	1969	1970	1971	1972	1973
Eastern Middle: Breakers and washeries	1,583	1,511	1,519	1,221	1,288
Western Middle:					
Breakers and washeries	2,806	2,540	2,167	1,741	1,663
Dredges	5	W	W	W	W
Total	2,811	W	W	W	W
Southern:					
Breakers and washeries	3,183	3,183	2,849	2,333	2,427
Dredges	530	W	W	W	W
Total	3,713	W	W	W	W
Northern: Breakers and washeries [1]	2,366	2,086	1,802	1,334	1,011
Total:					
Breakers and washeries	9,938	9,320	8,337	6,629	6,389
Dredges	535	409	390	477	441
Grand total	10,473	9,729	8,727	7,106	6,830

W Withheld to avoid disclosing individual company confidential data.
[1] Includes Sullivan County.

Table 9.—Pennsylvania anthracite produced in 1973, classified as fresh-mined, culm-bank, and river coal, by field and region

(Thousand short tons)

Source	Fresh-mined coal: Underground mines: Mechanically loaded	Hand loaded	Total [1]	Strip pits	From culm banks	From river dredging	Total [1]
FIELD							
Eastern Middle	--	--	--	865	422	--	1,288
Western Middle	32	67	99	620	944	W	W
Southern	222	237	460	1,110	857	W	W
Northern [2]	167	--	167	683	161	--	1,011
Total [1]	421	305	726	3,279	2,384	441	6,830
REGION							
Lehigh	--	--	--	1,162	611	--	1,773
Schuylkill	254	305	559	1,434	1,612	441	4,046
Wyoming	167	--	167	683	161	--	1,011
Total	421	305	726	3,279	2,384	441	6,830

W Withheld to avoid disclosing individual company confidential data.
[1] Data may not add to totals shown because of independent rounding.
[2] Includes Sullivan County.

Table 10.—Production of Pennsylvania anthracite from strip pits

	Mined by stripping (thousand short tons)	Percent of fresh-mined total	Number of men employed	Average number of days worked
1969	4,579	68.5	1,787	256
1970	4,541	72.3	1,855	234
1971	4,478	77.7	1,800	273
1972	3,483	78.7	2,011	261
1973:				
Lehigh region	1,162	29.0	NA	NA
Schuylkill region	1,434	35.8	NA	NA
Wyoming region [1]	683	17.1	NA	NA
Total or average	3,279	81.9	p 1,633	p 250

p Preliminary. NA Not available.
[1] Includes Sullivan County.

Table 11.—Employment at operations producing Pennsylvania anthracite (including strip contractors) in 1973

	Lehigh region	Schuylkill region	Wyoming region [1]	Total 1973 [p]	Total 1972
Average number of men working daily:					
Underground	NA	NA	NA	716	650
In strip pits	NA	NA	NA	1,633	2,011
At culm banks	NA	NA	NA	327	314
At preparation plants	NA	NA	NA	1,214	1,471
Other surface	NA	NA	NA	143	287
Total excluding dredge operations	NA	NA	NA	4,033	4,733
Dredge operations	NA	NA	NA	50	50
Total	NA	NA	NA	4,083	4,783
Average number of days active:					
All operations except dredges	NA	NA	NA	233	215
Dredge operations	NA	NA	NA	300	300
Average, all operations	NA	NA	NA	234	216
Man-days of labor:					
All operations except dredges	NA	NA	NA	940,000	1,018,000
Dredge operations	NA	NA	NA	15,000	15,000
Total, all operations	NA	NA	NA	955,000	1,033,000
Average tons per man-day:					
All operations except dredges	NA	NA	NA	6.80	6.51
Dredge operations	NA	NA	NA	29.41	31.79
Average, all operations	NA	NA	NA	7.15	6.88

[p] Preliminary. NA Not available.
[1] Includes Sullivan County.

Table 12.—Production of Pennsylvania anthracite from culm banks, by region

(Thousand short tons)

Year	Lehigh region	Schuylkill region	Wyoming region	Total [1]
1969	775	1,815	662	3,253
1970	921	1,591	524	3,036
1971	729	1,544	300	2,573
1972	614	1,411	177	2,202
1973	611	1,612	161	2,384

[1] Data may not add to totals shown because of independent rounding.

Table 13.—Estimated production of Pennsylvania anthracite in 1973, by week [1]

Week ended—	Thousand short tons	Week ended—	Thousand short tons	Week ended—	Thousand short tons
Jan. 6	107	May 12	150	Sept. 15	132
13	82	19	158	22	148
20	114	26	141	29	140
27	126	June 2	132	Oct. 6	133
Feb. 3	155	9	124	13	133
10	133	16	127	20	146
17	140	23	150	27	138
24	161	30	152	Nov. 3	116
Mar. 3	120	July 7	85	10	138
10	98	14	67	17	129
17	130	21	113	24	111
24	187	28	122	Dec. 1	152
31	178	Aug. 4	131	8	163
Apr. 7	137	11	132	15	144
14	142	18	115	22	97
21	134	25	129	29	115
28	139	Sept. 1	127	Total	6,830
May 5	145	8	112		

[1] Estimated from weekly carloadings as reported by the Association of American Railroads and other factors; adjusted to annual production from Bureau of Mines canvass.

Table 14.—Estimated monthly production of Pennsylvania anthracite [1]

(Thousand short tons)

Month	1969	1970	1971	1972	1973
January	973	808	725	583	522
February	911	770	654	542	568
March	898	814	780	622	641
April	916	759	795	487	581
May	869	763	782	706	641
June	812	809	740	515	609
July	704	707	620	465	434
August	877	898	813	688	587
September	947	880	767	611	532
October	985	895	710	682	614
November	831	815	685	650	582
December	750	811	656	555	519
Total	10,473	9,729	8,727	7,106	6,830

[1] Production is estimated from weekly carloadings, as reported by the Association of American Railroads, and includes mine fuel, coal sold locally, and dredge coal.

Table 15.—Power shovels, front-end loaders, and draglines used in recovering coal from culm banks and stripping Pennsylvania anthracite, by type of power

Type of power	1971				1972				1973			
	Number of front-end loaders	Number of power shovels	Number of draglines	Total	Number of front-end loaders	Number of power shovels	Number of draglines	Total	Number of front-end loaders	Number of power shovels	Number of draglines	Total
Gasoline	--	1	2	3	--	--	1	1	--	--	1	1
Electric	--	18	36	54	--	19	42	61	--	16	34	50
Diesel	77	43	85	205	103	41	75	219	138	34	77	249
Diesel-electric	--	--	1	1	--	--	--	--	--	--	--	--
Total	77	62	124	263	103	60	118	281	138	50	112	300

Table 16.—Pennsylvania anthracite loaded mechanically underground

Year	Scraper loaders		Mobile loaders		Conveyor [1] and pit-car loaders		Total [2] loaded mechanically	
	Number of units	Thousand short tons loaded	Number of units	Thousand short tons loaded	Number of units	Thousand short tons loaded	Number of units	Thousand short tons loaded
1969	106	567	25	190	158	570	289	1,327
1970	103	491	20	183	147	476	270	1,151
1971	95	319	18	151	91	199	204	670
1972	81	347	16	136	46	111	143	594
1973	72	220	4	106	47	96	123	421

[1] Includes duckbills and other self-loading conveyors.
[2] Data may not add to totals shown because of independent rounding.

Table 17.—Trends in mechanical loading,[1] hand loading, and stripping of Pennsylvania anthracite

Year	Fresh-mined coal							
	Underground					Strip pits		
	Mechanical loading (thousand short tons)	Percent of total underground	Hand loading (thousand short tons)	Percent of total underground	Total (thousand short tons)	Quantity (thousand short tons)	Percent of fresh mined coal	Total (thousand short tons)
1969	1,327	63.0	779	37.0	2,106	4,579	68.5	6,685
1970	1,151	66.1	591	33.9	1,742	4,541	72.3	6,283
1971	670	52.1	617	47.9	1,287	4,478	77.7	5,765
1972	594	62.9	350	37.1	944	3,483	78.7	4,427
1973	421	58.0	305	42.0	726	3,279	81.9	4,005

[1] Mechanical loading includes coal handled on pit-car loaders and hand-loaded face conveyors.

Table 18.—Distribution of Pennsylvania anthracite, by calendar year, by State, Province, and country of destination

(Net tons)

Destination	Pea and larger					Buckwheat No. 1 and smaller					Total all sizes
	Broken and egg	Stove	Chestnut	Pea	Total	Buckwheat No. 1	Buckwheat No. 2 (rice)	Buckwheat No. 3 (barley)	Other	Total	
1972											
United States:											
New England States:											
Connecticut	--	1,810	3,793	1	5,604	757	310	44	80	1,191	6,795
Maine	--	2,367	3,553	67	5,987	270	1,624	1	21	1,916	7,903
Massachusetts	404	11,672	8,760	787	21,623	1,504	3,231	1	1,479	6,215	27,838
New Hampshire	--	1,860	1,923	--	3,783	605	592	--	48	1,245	5,028
Rhode Island	--	519	619	--	1,138	--	--	--	126	126	1,264
Vermont	--	3,703	2,738	444	6,885	497	3,744	--	--	4,241	11,126
Total	404	21,931	21,386	1,299	45,020	3,633	9,501	46	1,754	14,934	59,954
Middle Atlantic States:											
New Jersey	1,166	20,878	46,383	7,836	76,263	11,077	5,022	1,432	87,905	105,436	181,699
New York	2,946	129,449	65,477	180,998	378,870	85,260	24,938	80,429	173,410	364,037	742,907
Pennsylvania [1]	5,522	168,002	424,932	331,517	929,973	452,996	533,164	476,802	1,423,273	2,886,235	3,816,208
Total	9,634	318,329	536,792	520,351	1,385,106	549,333	563,124	558,663	1,684,588	3,355,708	4,740,814
South Atlantic States: [2]											
Delaware	668	4,285	5,429	1,738	12,120	1,761	46	2,633	25	4,465	16,585
District of Columbia	--	2,569	2,291	259	5,119	888	918	16	72	1,894	7,013
Maryland	184	16,160	11,514	3,927	31,785	1,648	891	49	2,983	5,571	37,356
Virginia	--	1,463	448	137	2,048	100	161	7	1,578	1,846	3,894
Total	852	24,477	19,682	6,061	51,072	4,397	2,016	2,705	4,658	13,776	64,848
Lake States:											
Illinois	--	125	437	41	603	27,567	9,475	536	13,037	50,615	51,218
Indiana	--	--	2,055	13,485	15,540	418	180	445	26,056	27,099	42,639
Michigan	111	40,249	5,108	334	45,802	24	389	19	11,071	11,503	57,305
Minnesota	--	114	6	8	128	8	116	6	10,147	10,277	10,405
Ohio	9,550	44,893	928	6,387	61,758	23,181	2,730	117	40,999	67,027	128,785
Wisconsin	--	709	1,144	159	2,012	34	61	48	6,370	6,513	8,525
Total	9,661	86,090	9,678	20,414	125,843	51,232	12,951	1,171	107,680	173,034	298,877
Other States	--	29	580	21,172	21,781	62,913	3,916	20,995	268,752	356,576	378,357
Total United States	20,551	450,856	588,118	569,297	1,628,822	671,508	591,508	583,580	2,067,432	3,914,028	5,542,850
Canada											
Ontario	2,771	56,500	25,865	13,992	99,128	15,731	4,803	5,170	27,007	52,711	151,839
Quebec	479	3,304	4,526	9,805	18,114	33,312	8,734	136,583	150,045	328,674	346,788
Other Provinces	--	208	487	4	699	2	371	12	595	980	1,679
Total Canada	3,250	60,012	30,878	23,801	117,941	49,045	13,908	141,765	177,647	382,365	500,306
Other countries	54,837	226,320	116,171	21,016	418,344	388	217	22,639	249,285	272,529	690,873
Grand total	78,638	737,188	735,167	614,114	2,165,107	720,941	605,633	747,984	2,494,364	4,568,922	6,734,029

1973

United States:											
New England States:											
Connecticut	--	1,935	3,104	192	5,231	796	269	5	47	1,117	6,348
Maine	53	2,110	4,070	63	6,296	504	1,438	5	24	1,971	8,267
Massachusetts	554	11,950	8,693	695	21,892	1,132	4,202	2	242	5,578	27,470
New Hampshire	--	1,252	1,497	--	2,749	326	238	--	156	720	3,469
Rhode Island	--	553	685	--	1,238	47	--	--	14	61	1,299
Vermont	23	3,607	2,599	487	6,716	621	4,247	1	1	4,870	11,586
Total	630	21,407	20,648	1,437	44,122	3,426	10,394	13	484	14,317	58,439
Middle Atlantic States:											
New Jersey	664	16,628	37,070	7,078	61,440	7,111	3,908	715	78,975	90,709	152,149
New York	2,762	111,859	54,200	161,163	329,984	96,297	29,793	65,375	142,545	334,010	663,994
Pennsylvania [1]	26,335	201,938	399,675	289,149	917,097	362,095	465,748	389,124	1,349,070	2,566,037	3,483,134
Total	29,761	330,425	490,945	457,390	1,308,521	465,503	499,449	455,214	1,570,590	2,990,756	4,299,277
South Atlantic States: [2]											
Delaware	823	2,627	3,768	857	8,075	723	--	2,432	48	3,203	11,278
District of Columbia	--	1,657	1,342	405	3,404	1,607	343	--	1	1,951	5,355
Maryland	76	9,141	6,682	2,341	18,240	1,069	956	47	15,025	17,097	35,337
Virginia	138	934	501	3,850	5,423	102	886	203	2,200	3,391	8,814
West Virginia	--	22	2,739	20,973	23,734	27	4	50	39,742	39,823	63,557
Total	1,037	14,381	15,032	28,426	58,876	3,528	2,189	2,732	57,016	65,465	124,341
Lake States:											
Illinois	361	330	1,027	16,712	18,430	18,187	12,347	334	14,680	45,548	63,978
Indiana	--	--	1,231	9,816	11,047	26	82	1,556	28,146	29,810	40,857
Michigan	1,298	43,037	32,193	9,676	86,204	1,991	175	26	11,573	13,765	99,969
Minnesota	--	--	8	6	14	13	2	9	10,557	10,581	10,595
Ohio	6,655	11,899	377	1,415	20,346	30,291	2,536	66	74,626	107,519	127,865
Wisconsin	--	4,796	480	101	5,377	1,381	158	104	794	2,437	7,814
Total	8,314	60,062	35,316	37,726	141,418	51,889	15,300	2,095	140,376	209,660	351,078
Other States	200	13	420	7,402	8,035	54,304	3,391	19,548	264,470	341,713	349,748
Total United States	39,942	426,288	562,361	532,381	1,560,972	578,650	530,723	479,602	2,032,936	3,621,911	5,182,883
Canada											
Ontario	517	34,286	20,615	2,944	58,362	16,063	1,179	3,283	2,331	22,856	81,218
Quebec	437	10,898	1,556	3,099	15,990	31,634	3,662	156,433	186,939	378,668	394,658
Other Provinces	--	382	343	--	725	74	108	--	909	1,091	1,816
Total Canada	954	45,566	22,514	6,043	75,077	47,771	4,949	159,716	190,179	402,615	477,692
Other countries	67,106	236,187	109,032	19,966	432,291	43,909	356	1,061	203,736	249,062	681,353
Grand total	108,002	708,041	693,907	558,390	2,068,340	670,330	536,028	640,379	2,426,851	4,273,588	6,341,928

[1] Includes "Local sales."
[2] Shipments to other States in the South Atlantic area are included in "Other States."

Table 19.—Truck shipments of Pennsylvania anthracite in 1973, by month, and by State of destination[1]

(Thousand short tons)

Destination	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Percent of total trucked
Pennsylvania:														
Within region	143	145	118	129	123	103	88	130	143	127	144	118	1,511	40.1
Outside region	172	175	154	100	147	129	111	154	112	182	192	130	1,758	46.6
New York	37	46	28	33	37	29	23	31	25	33	33	25	380	10.1
New Jersey	9	8	7	4	5	5	4	6	6	7	7	9	77	2.0
Delaware	2	2	1	([2])	1	1	([2])	1	([2])	1	1	1	11	.3
Maryland	3	2	2	1	1	([2])	([2])	1	5	7	2	2	26	.7
District of Columbia	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Other States	1	1	([2])	([2])	([2])	([2])	([2])	([2])	1	3	1	1	8	.2
Total:														
1973	367	379	310	267	314	267	226	323	292	360	380	286	3,771	100.0
1972	356	403	439	299	318	230	216	304	301	384	380	336	3,966	100.0

[1] Compiled from reports of Pennsylvania Department of Mines and Mineral Industries; does not include dredge coal.
[2] Less than ½ unit.

Table 20.—Shipments of Pennsylvania anthracite, by destination[1]

(Thousand short tons)

Destination	1969	1970	1971	1972	1973
TRUCK SHIPMENTS					
Pennsylvania:					
Within region	1,918	1,847	1,880	1,584	1,511
Outside region	2,151	1,979	2,050	1,793	1,758
New York	369	418	373	441	380
New Jersey	247	198	126	89	77
Delaware	22	18	17	15	11
Maryland	94	50	29	23	26
District of Columbia	2	2	([2])	([2])	--
Other States	17	15	12	21	8
Total[3]	4,821	4,527	4,487	3,966	3,771
RAIL SHIPMENTS					
New England States	107	102	100	49	45
New York	645	455	532	281	299
New Jersey	291	173	113	85	55
Pennsylvania	940	847	819	830	856
Delaware	([2])	1	1	5	([2])
Maryland	34	19	24	2	1
District of Columbia	4	7	3	3	2
Virginia	6	9	7	3	8
Ohio	215	151	122	124	122
Indiana	70	66	54	42	43
Illinois	102	93	57	47	56
Wisconsin	6	12	8	10	8
Missouri	--	--	--	30	26
Minnesota	25	51	1	10	11
Iowa	--	--	--	31	36
Michigan	33	53	70	49	98
Other States	312	408	455	290	311
Total United States[3]	2,792	2,447	2,366	1,891	1,977
Canada	373	384	411	386	389
Other countries	853	691	572	374	384
Grand total[3]	4,018	3,522	[4] 3,349	2,651	2,750

[1] Compiled from reports of Pennsylvania Department of Mines and Mineral Industries; does not include dredge coal.
[2] Less than ½ unit.
[3] Data may not add to totals shown because of independent rounding.
[4] Corrected figure; erroneously reported in years 1971 and 1972.

Table 21.—Average sales realization of Pennsylvania anthracite (excluding dredge coal) at preparation plants, by region and size

(Per short ton)

Size	Lehigh region 1969	Lehigh region 1970	Lehigh region 1971	Lehigh region 1972	Lehigh region 1973	Schuylkill region 1969	Schuylkill region 1970	Schuylkill region 1971	Schuylkill region 1972	Schuylkill region 1973
Lump [1] and broken	--	--	--	--	--	--	--	$6.00	--	--
Egg	$14.16	$14.90	$17.59	$18.32	$19.77	$13.66	$14.27	16.83	$16.58	$17.32
Stove	14.05	14.98	16.62	17.67	19.37	13.92	15.35	16.65	17.56	19.35
Chestnut	14.08	15.19	16.47	17.39	19.11	13.84	15.29	16.58	17.23	18.96
Pea	11.75	13.56	14.60	15.60	16.36	11.91	13.46	15.00	15.33	16.86
Total pea and larger	13.43	14.65	16.14	17.08	18.64	13.38	14.81	16.21	16.87	18.52
Buckwheat No. 1	11.18	12.78	14.55	15.29	16.87	11.56	13.26	14.77	14.85	16.00
Buckwheat No. 2 (rice)	11.49	12.94	14.33	15.06	16.89	11.30	12.99	14.45	14.95	16.34
Buckwheat No. 3 (barley)	9.42	11.07	12.71	13.82	14.99	9.54	11.05	12.30	12.36	13.82
Buckwheat No. 4	5.92	7.16	8.51	8.82	10.68	6.67	7.60	8.00	9.15	10.87
Buckwheat No. 5	5.80	6.20	6.64	6.28	8.49	5.34	5.54	5.88	5.71	8.34
Other [2]	3.55	4.14	4.04	4.81	5.13	3.73	3.68	3.50	4.70	5.83
Total buckwheat No. 1 and smaller	8.39	8.51	9.78	10.09	11.55	7.76	8.77	9.39	9.43	10.66
Total all sizes	10.33	10.74	12.10	12.35	14.09	9.43	10.72	11.40	11.48	12.67

Size	Wyoming region [3] 1969	Wyoming region [3] 1970	Wyoming region [3] 1971	Wyoming region [3] 1972	Wyoming region [3] 1973	Total 1969	Total 1970	Total 1971	Total 1972	Total 1973
Lump [1] and broken	--	--	--	--	--	--	--	$6.00	--	--
Egg	$13.86	$15.62	$19.29	$18.46	$19.88	$13.95	$14.93	17.76	$18.11	$19.55
Stove	14.32	16.00	16.67	18.13	20.08	14.06	15.41	16.65	17.73	19.51
Chestnut	14.58	16.75	17.56	18.63	20.36	14.12	15.67	16.79	17.66	19.30
Pea	12.81	14.83	16.30	16.38	17.82	12.14	13.87	15.28	15.72	16.98
Total pea and larger	13.96	15.93	16.96	17.81	19.42	13.56	15.06	16.39	17.18	18.76
Buckwheat No. 1	11.77	13.62	15.15	16.23	17.46	11.53	13.26	14.83	15.38	16.60
Buckwheat No. 2 (rice)	11.79	13.77	15.17	15.60	17.93	11.47	13.14	14.56	15.12	16.77
Buckwheat No. 3 (barley)	9.43	11.07	13.13	13.87	13.91	9.49	11.06	12.56	12.97	14.11
Buckwheat No. 4	7.55	7.16	7.78	9.39	10.40	6.56	7.40	8.07	9.11	10.78
Buckwheat No. 5	4.65	4.41	6.61	7.22	8.96	5.47	5.65	6.08	5.93	8.39
Other [2]	1.98	4.50	6.24	6.60	7.15	3.16	4.00	4.44	5.16	5.78
Total buckwheat No. 1 and smaller	7.88	9.56	11.50	12.71	13.85	7.93	8.92	9.90	10.14	11.30
Total all sizes	10.51	12.09	13.70	14.94	16.33	9.91	11.03	12.08	12.40	13.65

[1] Quantity of lump included is insignificant.
[2] Includes various mixtures of buckwheat Nos. 2 to 5 and coal of relatively low dollar value.
[3] Includes Sullivan County.

Table 22.—Average value of Pennsylvania anthracite from all sources, by region [1]

(Per short ton)

Region	1972				1973			
	Shipped by rail	Shipped by truck	Colliery fuel	Total	Shipped by rail	Shipped by truck	Colliery fuel	Total
Lehigh	$13.41	$11.50	$15.61	$12.35	$15.46	$12.72	$16.31	$14.10
Schuylkill	10.04	11.52	14.36	10.88	11.75	12.29	14.01	12.05
Wyoming [2]	14.92	14.95	15.94	14.94	16.26	16.35	16.39	16.33
Total	11.56	12.29	15.21	12.00	13.30	13.15	15.11	13.22

[1] Value given for shipments is that at which coal left possession of producing company; does not include selling expenses.
[2] Includes Sullivan County.

Table 23.—Wholesale prices of Pennsylvania anthracite in 1973, by size [1]

(Per short ton)

Size	Winter	Spring	Summer-Fall	End of year
Egg and stove	$19.75–$19.90	$20.75–$20.85	$21.75–$22.50	$22.50–$23.50
Chestnut	19.50	20.00	21.00– 21.50	21.50– 22.50
Pea	17.50	18.00	19.00	19.40– 19.60
Buckwheat No. 1	17.50	18.00	19.00	19.40– 19.60
Buckwheat No. 2 (rice)	17.50	18.00	19.00	19.40– 19.60
Buckwheat No. 3 (barley)	16.50	17.00	18.00	18.50

[1] As quoted in the Black Diamond Magazine. All prices are per short ton f.o.b at mines.

Table 24.—Consumption of Pennsylvania anthracite in the United States, by consumer category

(Thousand short tons)

Year	Residential and commercial heating [e]	Colliery fuel	Electric utilities [1]	Cement plants	Iron and steel industry		Other uses [e]
					Coke making	Sintering and pelletizing [2]	
1969	4,209	17	1,849	213	543	623	1,355
1970	4,042	16	1,897	W	472	464	1,357
1971	3,850	15	1,646	W	421	339	1,037
1972	2,960	11	1,584	W	474	283	603
1973	2,917	11	1,442	W	[r] 467	231	603

[e] Estimate. [r] Revised. W Withheld to avoid disclosing individual company confidential data; included in "Other uses."
[1] Federal Power Commission.
[2] Annual Statistical Report, American Iron and Steel Institute.

Table 25.—U.S. exports of anthracite, by country and customs district

	1972		1973	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
COUNTRY				
Argentina	2,721	$68	2,216	$28
Australia	1,477	90	2,373	156
Brazil	3,496	237	2,475	175
Canada	500,306	6,641	477,692	6,897
Chile	4,288	81	4,712	61
Colombia	893	70	512	14
Denmark	--	--	279	3
Dominican Republic	--	--	545	7
Finland	--	--	532	9
France	154,918	2,291	105,511	1,500
India	55	1	4,257	136
Indonesia	--	--	653	8
Iran	55	5	122	12
Italy	32,463	499	28,008	395
Mexico	6,903	184	8,303	240
Netherlands	8	1	39,221	543
Philippines	662	29	1,213	45
Surinam	263	17	250	17
Sweden	9,240	146	9,604	214
Venezuela	13,894	345	26,796	748
Yugoslavia	10,987	198	--	--
Other	822	19	1,272	32
Total	743,451	10,922	716,546	11,240
CUSTOMS DISTRICT				
Baltimore	748	37	2,207	154
Buffalo	115,669	1,838	83,506	1,746
Cleveland	17,772	369	--	--
Detroit	5,675	83	12,477	183
Houston	1,091	56	--	--
Laredo	6,903	184	7,762	231
Miami	--	--	179	3
Mobile	10	(1)	12	1
New Orleans	3,486	236	3,457	250
New York City	1,343	44	3,028	91
Norfolk	4,856	78	--	--
Ogdensburg	33,216	590	27,220	525
Pembina	695	20	3,131	60
Philadelphia	551,987	7,387	571,603	7,921
Port Arthur	--	--	1,045	65
Savannah	--	--	355	4
Seattle	--	--	564	6
Total	743,451	10,922	716,546	11,240

[1] Less than ½ unit.

NOTE:—According to the Association of American Railroads, 659,516 short tons of anthracite were exported to Europe during 1973, compared with 697,092 short tons for 1972. Of this total 436,507 short tons were consigned to West Germany and the Netherlands, including exports to the U.S. military forces. This compares with 464,688 short tons for 1972.

Table 26.—Anthracite:[1] World production, by country

(Thousand short tons)

Country[2]	1971	1972	1973[p]
Belgium	3,715	3,258	2,759
Bulgaria	176	171	141
China, People's Republic of[e]	22,000	22,000	22,000
France	10,118	9,353	[e] 7,700
Germany, West	10,935	8,793	7,010
Ireland	30	[r] [e] 22	[e] 22
Japan	549	504	239
Korea, North[e]	26,800	30,100	33,100
Korea, Republic of	14,093	13,672	14,959
Morocco	524	603	623
Netherlands	4,183	3,174	[e] 2,100
Peru	12	[r] [e] 11	[e] 11
Portugal	279	278	301
Romania[e]	16	16	16
South Africa, Republic of	2,029	1,473	1,552
Spain	3,170	3,312	3,272
U.S.S.R	83,511	83,133	[e] 83,200
United Kingdom	[r] 4,546	3,433	2,784
United States (Pennsylvania)	8,727	7,106	6,830
Vietnam, North[e]	3,300	2,200	3,300
Total	[r] 198,713	192,612	191,919

[e] Estimate. [p] Preliminary. [r] Revised.

[1] An unspecified amount of semianthracite is included in figures for some countries.

[2] In addition to the countries listed, Canada, Colombia, New Zealand, and South Vietnam produce anthracite, but the level of production is not recorded and available information is inadequate to make reliable estimates; in Colombia output may total 100,000 tons annually, while in New Zealand and South Vietnam output is insignificant.

Cobalt

By John D. Corrick [1]

Demand for cobalt in 1973 continued the upward trend that began in 1972 and reflected a general increase in the industrial activities of the Nation. High-purity metal including cobalt powder, and salts and driers were in greatest demand during 1973. Consumer stocks in 1973 began to rebound from their low levels of 1971 and 1972. Government releases of cobalt from the strategic stockpile were again a significant source of supply during 1973 with over 8.5 million pounds released.

Legislation and Government Programs.—General Services Administration (GSA) continued to offer specification-grade cobalt metal in various forms for sale during 1973. Sales were on an unrestricted-bid basis except that total sales of specification-grade material were limited to approximately 1 million pounds per month and 500,000 pounds per bidder per month. Government sales of cobalt for the year totaled 7,500,589 pounds compared with 8,629,692 pounds sold in 1972. The stockpile objective for cobalt was lowered from 38,200,000 to 11,945,000 pounds in 1973. The action was taken under Section 2(a) of Public Law 520 (79th Congress), Reorganization Plan No. 1 of 1958, as amended, and Executive Order 11051.

As of December 31, 1973, total U.S. Government stockpile inventory was 62,930,793 pounds of cobalt. Of this quantity, 62,380,307 pounds was stockpile grade.

Table 1.—Salient cobalt statistics

(Thousand pounds of contained cobalt)

	1969	1970	1971	1972	1973
United States:					
Consumption	15,608	13,367	12,500	14,130	18,741
Imports for consumption	12,911	12,417	10,912	13,915	19,200
Stocks, Dec. 31: Consumer	2,191	1,890	1,411	1,193	2,451
Price: Metal, per pound	$1.85–$2.20	$2.20	$2.20–$2.45	$2.45	$2.45–$3.10
World: Production, mine	43,556	52,590	54,598	51,850	56,510

DOMESTIC PRODUCTION

There was no domestic mine production of cobalt in 1973. Nevertheless, Amax Nickel, a division of American Metal Climax Inc., continued to renovate its Port Nickel, La., refinery. When the refinery becomes operational early in 1974 it will have a capacity to produce over 80 million pounds of nickel per year plus substantial quantities of cobalt, copper, and associated byproduct metals depending on feed material.

[1] Physical scientist, Division of Ferrous Metals—Mineral Supply.

CONSUMPTION AND USES

Consumption of cobalt in the United States in 1973 was 18.7 million pounds, 33% above that of 1972 and exceeded the 1969 record consumption by 20%. Increased consumption was a direct result of a rise in industrial activity that began in the latter half of 1972 and continued strong through 1973. The pattern of cobalt consumption was little changed from that of 1972 with major consumption occurring in magnetic alloys, salts and driers, superalloys, and cutting and wear-resistant materials. Data reported by consumers showed that of the cobalt consumed in the United States in 1973, 75% was as metal, 19% was as salts and driers, 4% was as oxide, and 2% was as purchased scrap.

Huntington Alloys Products Division, of International Nickel Co. of Canada Ltd. (Inco), marketed a new nickel iron-cobalt alloy, Incoloy 903. Principal uses for the low thermal expansion alloy will be in rocket engines, gas turbines, and special instruments in which high stresses are a problem. According to company officials, Incoloy 903, hardened with additions of aluminum, columbium, and titanium, has greater thermal conductivity than many other high-stress alloys and performs over a temperature range of minus 43° to plus 1,200° F.[2] General Electric Co. introduced a new superalloy in 1973 designated Rene 95. Company officials believed the alloy would find wide use in turbine blades and compressor discs. Forgings of the alloy offered extremely high strengths up to temperatures of 1,200° F.

A National Aeronautics and Space Administration (NASA) fluoride-metal composite impregnated into porous nickel, cobalt, or iron alloys was to be marketed for the first time in 1973 by Astro Met Associates of Cincinnati, Ohio. The self-lubricating alloy may find applications in rotary engines like the Wankel.[3]

Hitachi Magnetics Corp. of Japan announced their first commercial production of samarium-cobalt material for use in making powerful magnets having strengths of 16 to 23 million gauss-oersteds. Hitachi Metals, America, acquired the magnetic materials facilities of General Electric at Edmore, Mich., in March 1973. The magnets will be marketed worldwide under the name Hicorex.[4]

E. I. du Pont de Nemours & Co. introduced a new intermetallic compound and designated it Tribaloy. The new material was reportedly resistant to wear, friction, and corrosion. Tribaloy was expected to compete with stainless steel types 304 and 316, nickel base alloys, tungsten carbide, and some superalloys. The cobalt-based alloy was expected to be used in plasma flame spraying of heavy duty brakes, journal or sleeve bearings, ball and roller bearings, cams, pump and valve parts, and seals.[5]

PRICES

The producer price of $2.45 per pound for cobalt metal granules (shot) or broken cathodes in 551-pound (250-kilogram) drums was increased to $3 in February and to $3.30 on August 13. Eighteen days later the price was adjusted downward to $3.20 per pound where it remained until November 28, when the price was adjusted to $3.10 per pound, f.o.b. New York or Chicago. A weighted average price for the year was calculated to be $3 per pound of cobalt.

Sales of cobalt metal by the Government on a "sealed-bid" basis ranged in price from $2.3851 to $2.988 per pound for specification-grade material. All prices were f.o.b. carrier's conveyance at Government storage locations.

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[2] American Metal Market. Nickel-Iron-Cobalt Forms Incoloy 903. V. 80, No. 198, Oct. 11, 1973, p. 9.

[3] Metal Bulletin No. 5828, Aug. 24, 1973, 122, June 22, 1973, p. 7. p. 20.

[4] American Metal Market. Hitachi Magnetics Starts Samarium Cobalt Production. V. 80, No.

[5] Iron Age. Cobalt Materials Fight Wear and Corrosion V. 211, No. 16, Apr. 19, 1973. pp. 63–64

Table 2.—Cobalt materials consumed by refiners or processors in the United States

(Thousand pounds of contained cobalt)

Form [1]	1969	1970	1971	1972	1973
Alloy and concentrate	516	274	356	r 120	14
Metal	2,819	2,639	2,899	3,063	4,028
Hydrate	25	32	18	16	60
Other	1	9	9	16	26

r Revised.

[1] Total consumption is not shown because some metal and hydrate originated from alloy and concentrate and a total would involve duplication.

Table 3.—Cobalt products [1] produced and shipped by refiners and processors in the United States

(Thousand pounds)

	1972				1973			
	Production		Shipments		Production		Shipments	
	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content
Oxide	651	459	824	581	880	622	1,161	819
Hydrate	830	513	788	487	1,021	631	1,036	640
Salts [2]	5,354	1,336	5,382	1,361	8,503	1,944	8,373	1,962
Driers	9,623	834	9,771	843	11,002	922	11,589	967
Total	16,458	3,142	16,765	3,272	21,406	4,119	22,159	4,388

[1] Figures on metal withheld to avoid disclosing individual company data.
[2] Combined to avoid disclosing individual company confidential data.

Table 4.—Cobalt consumed in the United States, by end use

(Thousand pounds of contained cobalt)

Use	1973
Steel:	
Carbon	2
Stainless and heat-resisting	32
Full alloy	226
High-strength, low-alloy	45
Electric	W
Tool	518
Cast irons	W
Superalloys	3,282
Alloys (excludes alloy steels and superalloys):	
Cutting and wear-resistant materials [1]	2,511
Welding and alloy hard-facing rods and materials	391
Magnetic alloys	4,302
Nonferrous alloys	789
Other alloys	755
Mill products made from metal powder	W
Chemical and ceramic uses:	
Pigments	217
Catalysts	1,150
Ground coat frit	165
Glass decolorizer	64
Other	197
Miscellaneous and unspecified	526
Total	15,172
Salts and driers: Lacquers, varnishes, paints, ink, pigments, enamels, glazes, feed, electroplating, etc	3,569
Grand total	18,741

W Withheld to avoid disclosing individual company confidential data; included in "Miscellaneous and unspecified."

[1] Includes cemented and sintered carbide and cast carbide dies or parts.

Table 5.—Cobalt consumed in the United States, by form

(Thousand pounds of contained cobalt)

Form	1969	1970	1971	1972	1973
Metal	12,057	10,056	9,006	10,509	14,050
Oxide	646	626	625	733	668
Purchased scrap	328	69	125	197	454
Salts and driers	2,577	2,616	2,744	2,691	3,569
Total	15,608	13,367	12,500	14,130	18,741

FOREIGN TRADE

Exports of unwrought cobalt metal and alloys and of waste and scrap totaled 2,492,730 pounds, gross weight, having a value of $4,193,595 and went to 18 countries. Japan and the United Kingdom received the greater part, 1,498,246 pounds ($2,484,652) and 374,385 pounds ($399,825), respectively. Exports of wrought cobalt metal and alloys, 1,396,938 pounds, gross weight, having a value of $4,738,396, went to 26 countries. The imports of cobalt salts and compounds given in table 7 came principally from the United Kingdom and France.

Table 6.—U.S. imports for consumption of cobalt metal and oxide, by country

(Thousand pounds, and thousand dollars)

Country	Metal				Oxide			
	1972		1973		1972		1973	
	Gross weight	Value	Gross weight	Value	Gross weight	Value	Gross weight	Value
Australia	--	--	5	5	--	--	--	--
Belgium-Luxembourg	3,344	8,242	4,209	13,616	878	1,913	847	2,158
Canada	633	1,540	502	1,458	221	342	228	355
Dominican Republic	--	--	23	74	--	--	--	--
Finland	1,299	3,189	909	2,850	--	--	--	--
France	500	1,035	197	404	--	--	--	--
Germany, West	12	25	39	76	--	--	--	--
Italy	--	--	45	33	(1)	1	--	--
Japan	45	118	5	6	--	--	--	--
Netherlands	49	67	16	27	--	--	--	--
Norway	915	2,083	972	2,995	--	--	--	--
Taiwan	--	--	55	224	--	--	--	--
United Kingdom	131	142	187	223	(1)	(1)	75	201
Zaire	5,083	11,602	11,196	31,634	35	74	--	--
Zambia	1,071	2,607	--	--	--	--	--	--
Total	13,082	30,650	18,360	53,625	1,134	2,330	1,150	2,714

[1] Less than ½ unit.

Table 7.—U.S. imports for consumption of cobalt, by class

(Thousand pounds and thousand dollars)

Year	Metal		Oxide		Salts and compounds		Total	
	Gross weight	Value	Gross weight	Value	Gross weight	Value	Gross weight	Cobalt content [e]
1971	10,381	22,377	726	1,426	40	27	11,147	10,912
1972	13,082	30,650	1,134	2,330	82	44	14,298	13,915
1973	18,360	53,625	1,150	2,714	58	50	19,568	19,200

[e] Estimate.

WORLD REVIEW

Aided by United States Government stockpile releases, cobalt production in the Non-Communist countries was sufficient to meet demand in 1973. Zaire again led all countries in mine production of cobalt and accounted for 59% of the total world output. Cobalt production in 1973 increased in all major producing countries except Zambia and Morocco when compared with that of 1972.

Australia.—Development of the Greenvale nickeliferous laterite deposit by Freeport Queensland Nickel Inc., a wholly-owned subsidiary of Freeport Minerals Co. of the United States, and Metals Exploration N. L. of Australia continued on schedule during 1973. Early in 1973 a contract was let for the construction of the town of Greenvale in Queensland. At the same time the treatment plant foundation was poured at Yabulu, near the coast, 140 miles from the mine site. Stripping of the mine overburden began early in 1973 as did construction of a 140-mile-long railway connecting the mine at Greenvale with the Yabulu treatment plant. The plant was designed to treat a million dry tons of ore annually and produce over 50 million pounds of nickel and 2.75 million pounds of cobalt in the form of nickel-cobalt sulfide. The hydrometallurgical process to be used was based on ammoniacal leaching of the pyrometallurgically reduced ore. At yearend production was still scheduled for 1974. Ore reserves were officially stated as 44 million tons containing 1.57% nickel and 0.12% cobalt.

Belgium.—A 3-week strike at the Olen refinery in Hoboken, Belgium, operated by Société Générale de Belgique created a temporary shortage of cobalt metal powder in 1973. Settlement of the labor dispute was expected to increase wages by approximately 17%. The cobalt refinery at Olen had an annual capacity of approximately 11 million pounds.

Canada.—Mine production of cobalt increased in 1973 by 18% compared with that of 1972. Inco's deliveries of cobalt were 1,870,000 pounds in 1973 compared with the 2,210,000 pounds in 1972 and 1,980,000 pounds in 1971. In October Inco opened its new Copper Cliff nickel refinery in Sudbury, Ontario. The refinery and ancillary facilities cost approximately $140 million. Annual capacity was placed at 100 million pounds of nickel pellets and nickel-iron powder. Electrolytic copper, cobalt, and precious metals will be recovered from the refinery residue as a byproduct. Falconbridge Nickel Mines, Ltd., was able to increase deliveries of cobalt in 1973 to 1,614,000 pounds compared with 1,150,000 pounds in 1972 as a result of commissioning of a new cobalt refinery at Kristiansand, Norway. The Kristiansand cobalt refinery was destroyed by a fire in May 1972. According to company officials, the stockpile of cobalt residue that accumulated during the shutdown should be exhausted by the end of 1974. Reportedly Sherritt Gordon Mines Ltd. produced 616,000 pounds of cobalt in 1973 compared with 809,000 pounds in 1972. Cobalt sales for the 2 years were 569,000 and 713,000, respectively.

Cuba.—Cuba rearranged the sales price of cobalt to the U.S.S.R. to $2.27 per pound of contained cobalt as part of the recent Cuban-U.S.S.R. plan to renovate and modernize both the Moa Bay and Nicaro nickel-cobalt facilities and develop the new Punta Gorda nickel deposits. Estimates are that the renovation and construction of a new plant will double Cuba's output of nickel and cobalt over the next 3 years.

Finland.—The completion in 1973 of a major long-term investment program by the Finnish company Outokumpu Oy should permit Finland to increase mine output of cobalt in the near future. Upon completion of the program, the concentrator and mine at Vuonos had a capacity to produce 72,000 tons per year of cobalt-rich iron-pyrites. The Kokkola refinery treated the nickel, copper, and zinc-bearing cobalt-rich pyrites (cobalt content of about 0.7%) using the Outokumpu process. The plant had an annual capacity of about 2.6 million pounds of cobalt or about 5% of the world's production. Cobalt was produced as a metal and sold in the form of powder or briquets.

India.—Reportedly work began in 1973 on the development of India's largest known nickel deposit at Sukinda, in the eastern state of Orissa. The project will cost approximately $43 million and was expected to produce 5,300 tons per year of nickel, 200 tons per year of cobalt, and 19,000 tons per year of byproduct ammonium sulfate. The State-owned Hindustan Copper Ltd.

was to manage the project until a separate corporation could be formed.

Indonesia.—To date, the largest planned Indonesian nickel-cobalt operation was that of P. T. Pacific Nickel Indonesia in which Sherritt Gordon held a 10% interest. Activities in 1973 were limited to engineering studies pending development of a financing plan acceptable to shareholder companies. During the year Internatio-Muller N.V. withdrew from the project and sold its 10% interest to the other four participants. The project involved the development of a laterite deposit on Gag Island, Irian Barat.

P. T. International Nickel Indonesia, a wholly owned subsidiary of Inco, announced in April 1973 a decision to proceed with the first phase of a lateritic mining and processing project on the island of Sulawesi. At yearend construction had begun and contracts were awarded to the Dravo Corp. for engineering and construction of the processing plant and project infrastructure and to the Montreal Engineering Co., Ltd., for engineering of the town site. The plant, to become operational in 1976, was to have a production capacity of over 15,000 tons of nickel plus cobalt per year in the form of 75% nickel matte.

Morocco.—Cobalt production in 1973 was 1,567 tons in the form of 14% cobalt concentrate compared with 1,766 tons in 1972. Production came from one mine in southern Morocco, 65% owned by the French firm Omnium Nord-African and 35% by Bureau de Recherches et de Participations Minières (BRPM). Ore reserves were estimated as being sufficient to last 8 to 10 years at the current rate of production. Exports in 1972 were up 125% over those of 1971. Of the cobalt exported 7,800 tons went to France and 3,205 to the People's Republic of China. Under a prior agreement, Soviet geologists have combined a search for cobalt deposits in Morocco with a study of the Rif mountains .

Philippines.—Construction of the Nonoc nickel refinery by Marinduque Mining and Industrial Corp. made significant progress in 1973. Procurement of engineering equipment was completed in 1973. During the year, pier facilities for ocean-going tankers and a tank farm were completed, a three-quarter mile long airstrip became operational, all-weather roads were completed, and housing for junior and senior staff members neared completion. Also, nearing completion at yearend was a dam on the Sabang River in northern Dinagat Island designed to provide water and standby power for the Nonoc operation. The first mining block was developed in 1973. Production was expected to begin in August 1974. With a designed capacity of 3.8 million dry tons of ore annually, the refinery will not only make the Philippines the largest producer of pure nickel in Southeast Asia but will produce 3.3 million pounds of cobalt per year in the form of mixed sulfides.

Pacific Metals Co., subsidiary of Nippon Steel, of Japan agreed to purchase Universal Oil Products Co.'s 40% interest in Rio Tuba Nickel Mining Corp. Rio Tuba expected to develop a mine on Palawan Island in the Philippines at an estimated cost of $50 million. This included a 1-million-ton-per-year ore operation, an ore treatment plant, and a ship-loading facility. Plans called for mining of 2 million tons of ore per year. The lower grade ore would require treatment such as smelting and would be considered at a later date. The higher-grade ore would be shipped to Japan for processing. A. Soriano Corp. continued their evaluation of an ore deposit on Palawan Island during 1973. A feasibility study completed in 1973 detailed a plant to produce 35 million pounds of nickel per year and 1.3 million pounds of cobalt per year at a cost of $125 million, including infrastructure. The company was studying during 1973 a $175 million leach plant with an annual capacity of 60 million pounds of nickel plus cobalt. Plant products would be in the form of a nickel sinter oxide 90 and a mixed nickel-cobalt sulfide.

Uganda.—The Ugandan Government offered new terms to Kilembe Copper Cobalt Ltd. for renewal or extension of the company's 21-year lease on the Kilembe mines which expired at the end of 1973. The Government owned 10% of Kilembe mines, and Falconbridge Nickel owned 72.8% of Kilembe Copper Cobalt which in turn owned 70% of Kilembe mines. Indications were that production increased in 1973 compared with 1972, following settlement of labor problems that arose from the expulsion of technicians by the Government in 1972.

Zaire.—Zaire, through the state holding company, La Générale des Carrières et Mines du Zaire (GECAMINES) and its operating company La Générale Congolaise des Minérais (GECOMIN) produced over 33 million pounds of cobalt in 1973 and accounted for over 59% of the total world mine output. Early in 1973 GECAMINES increased the feed rate capacity of its concentrator at Kambove from 1.08 million tons of ore per year to 1.44 million tons per year. Ore for the concentrator was supplied principally from the Kambove underground mine, which had a capacity of 960,000 tons per year in 1973. The mine was being expanded in 1973 to a capacity of 1.44 million tons per year in order to supply the concentrator. The deficit between the concentrator capacity and mine capacity in 1973 was made up from open pit mines in the area. Officials of GECAMINES announced during 1973 that the company had discovered a new deposit estimated at 121.5 million tons of ore containing 3.8% copper and 0.4% cobalt near Dikuluwe-Mashamba, southwest of Kolwezi. At yearend the acting director general of GECAMINES announced details of its 1974–77 expansion plan. Under the plan two new open pit mines would be commissioned in the area of the newly discovered deposits. The major purchasing effort would be in the metallurgical processing field and would be aimed at increasing domestic refining capacity. The plan when completed was expected to increase cobalt production to 18,000 tons per year. The cost of the new 5-year expansion plan was estimated at $160 million and included improvements to industrial and social infrastructure.

Société Minière de Tenke-Fungurume (SMTF) was formed in 1970 to explore and develop copper-cobalt deposits in the Tenke-Fungurume district of Zaire. The shareholders in the company and their respective interests were: Zairian Government, 20%; Charter Consolidated, Ltd. (UK), 28%; Amoco Minerals Co., a subsidiary of Standard Oil Co. of Indiana (U.S.), 28%; Mitsui & Co. (Japan), 14%; Bureau de Recherches Géologiques et Minières (BRGM) (France), 3.5%; Omnium de Mines S.A. (France), 3.5%; and Leon Templesman & Sons, Inc. (U.S.), 3%. At the end of 1972 SMTF had completed 350 test boreholes with a combined length of 153,845 feet. Ore reserves were estimated at 45.7 million tons of oxide mixed with sulfide and contained 5.5% copper and 0.44% cobalt. The oxide portion was estimated at 20.4 million tons of ore containing 5.6% acid soluble copper and 0.39% acid soluble cobalt. Parsons-Jurden Corp., a division of the Ralph M. Parsons Co. of Los Angeles, Calif., and Holmes & Narver, Inc. were awarded a contract as consultants to SMTF in 1973. The consultants began an independent review and validation of earlier technical and economic feasibility studies and were in an advanced state at yearend 1973. SMTF reportedly was concerned over the supply of adequate electrical power to the area and was attempting to coordinate its financing and construction plans with those of the Inga-Shaba high-voltage transmission project being planned by the Zairian Government. The company planned to begin production shortly after the completion of the power project, sometime in 1977. Capital expenditures for SMTF's copper-cobalt project were estimated at $300 million. The company employed approximately 1,000 people in 1973.

Zambia.—On January 9, 1973, Rhodesia closed its common border with Zambia causing the latter country to seek alternate routes for shipping its copper and cobalt to world markets. The company instituted emergency plans which included expanding the road services to Dar es Salaam and Mombasa, and extending the use of the rail route to Lobito. While the task of rerouting the flow of materials presented some problems, the sale and movement of cobalt was not unduly affected. Cobalt sales for the period ending March 31, 1973, were reported at slightly over 6 million pounds of cobalt compared with sales of 5.4 million pounds in 1972.

The Zambian Government in 1973 appeared to be moving ahead with its plans to gain full control of the country's copper and cobalt mining operations. During the year President Kenneth Kaunda announced major policy changes that affected Zambia's mining sector. The immediate impact of President Kaunda's action toward the minority shareholders in Nchanga Consolidated Copper Mines Ltd. (NCCM) and Roan Consolidated Mines Ltd. (RCM) was not known at yearend. Although the president did remark that steps were to be taken to insure that RCM and NCCM provide for themselves all management and technical services which are now provided by the minority shareholders. One major step taken toward industrial nationalization in 1973 was the merging of the research and development units of NCCM and RCM. Plans were discussed during 1973 for the development of a new process to produce cobalt from converter slag. The process would improve the efficiency of smelter furnaces.

Table 8.—Cobalt: World production by country

(Short tons)

Country	Mine output, metal content [1]			Metal [2]		
	1971	1972	1973 p	1971	1972	1973 p
Australia	r 877	830	840	--	--	--
Canada [3]	r 2,161	1,676	1,973	1,204	1,323	1,146
Cuba e	1,700	1,700	1,800	--	--	--
Finland e	1,400	1,400	1,400	1,020	885	1,113
France [4]	--	--	--	635	853	e 880
Germany, West [4]	--	--	--	662	504	408
Morocco	1,078	1,766	1,567	--	--	--
Norway	NA	NA	NA	[5] 958	[5] 353	e [5] 820
U.S.S.R. e [6]	1,750	1,800	1,850	1,750	1,800	1,850
United States	W	--	--	154	--	--
Zaire	r [7] 16,003	14,453	16,625	16,003	14,377	16,592
Zambia	e r [8] 2,330	e [8] 2,300	e [8] 2,200	r 2,293	2,263	2,143
Total	r 27,299	25,925	28,255	r 24,679	22,358	24,952

e Estimate. p Preliminary. r Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data.

[1] In addition to the countries listed, Bulgaria, Cyprus, East Germany, New Caledonia, Poland, Spain and Sweden are known to produce ores (copper, nickel and/or pyrite) that contain recoverable quantities of cobalt, but available information is inadequate to make reliable estimates of output levels. Other nations may also produce cobalt as a byproduct component of ores and concentrates of other metals.

[2] In addition to the countries listed, the United Kingdom recovers cobalt metal from intermediate metallurgical products produced in Canada, but data on output is inseparable from the total reported by Canadian producers, and Czechoslovakia presumably recovers cobalt from materials imported from Cuba, but data are inadequate to estimate output. Belgium and Japan, both of which import substantial quantities of crude materials containing cobalt, have not recorded output in recent years, but may be producing metal and/or cobalt compounds. Poland also apparently processes cobalt-bearing copper ores but no data on cobalt recovery are available.

[3] Actual output not reported.. Data presented for mine output are total cobalt content of all products, including nickel oxide sinter shipped to the United Kingdom for further processing and nickel-copper matte shipped to Norway for further processing. Data presented for metal output are total cobalt content of all products less cobalt output recorded for Norway. Thus, the metal data include cobalt content of oxides and other compounds that are not produced as metal and total cobalt metal output in the United Kingdom as well as actual metal output in Canada itself.

[4] Domestic mine output, if any, is negligible.

[5] Produced entirely from nickel-cobalt matte imported from Canada; domestic mine output is recovered abroad.

[6] Insufficient data are available to permit separate estimates for mine and metal production

[7] Metal output, used in lieu of unreported mine production.

[8] Figures include reported metal production plus an estimate for cobalt content of cobalt hydroxide produced.

TECHNOLOGY

Bureau of Mines scientists filed an invention report in 1973 in which they described an efficient extraction and treatment process for low-grade lateritic ores. The oxide ore was selectively reduced and leached in an ammonia-ammonium sulfate system to recover 90% of the nickel and more than 80% of the cobalt. The nickel was selectively separated by liquid extraction and subsequently recovered by electrolysis; cobalt was precipitated from the leach solution as a cobalt sulfide. Bureau researchers continued investigations into the development of economic methods for beneficating low-grade domestic ores containing cobalt in 1973. Bureau metallurgists reported on the preparation of samarium-cobalt permanent magnets. The method used to fabricate the magnets consisted of arc-melting, crushing and grinding the alloy, alining and pressing the powder, and sintering the green compacts. Optimum composition was reported to be 36.7 ± 0.3 weight-percent samarium and 63.3 ± 0.3 weight-percent cobalt.[6]

A new process for the recovery of nickel and cobalt from limonites by aqueous chlorination in seawater was described in a

[6] Walkiewicz, J. W., J. S. Winston, and M. M. Wong. Preparation of Samarium-Cobalt Permanent Magnets. BuMines RI 7784, 1973, 18 pp.

joint paper by scientists of Dartmouth College at Hanover, N. H., and of Delft University of Technology at Delft, the Netherlands.[7] The process was based on selective reduction of the ore pyrometallurgically and on aqueous chlorination in seawater. Reportedly, advantages gained from the process were high recovery of nickel and cobalt, rapid dissolution rates, and the use of saline in place of fresh water.

The second International Symposium on Superalloys was held in 1973. The subjects covered at the symposium were melting and casting of superalloys, primary working of superalloys, control of superalloy properties through thermal and deformation techniques, fabrication of superalloys, and new processes and alloy developments in superalloys. The latter session dealt with the ramifications of powder metallurgy as they applied to superalloys.

As in the past years, a large number of patents were issued in the United States and abroad, ranging from extractive metallurgy through smelting technology to the formation of new cobalt alloys. A large number of the patents issued during 1973 dealt with the extraction and recovery of cobalt from lateritic ores. Of the patents issued for extraction of cobalt from ores, a large portion dealt with the liquid extraction of cobalt values using an ammonia-ammonium process. A patent was assigned to Deepsea Ventures, Inc. for the extraction of manganese, copper, cobalt, and nickel from ocean-floor manganese nodules. The process described in the patent specified the pelletization of a mixture of nodules, coal, and sodium chloride. The pellets were contacted with chlorine gas under conditions that vaporize the metal chlorides along with water and oxides of carbon. The metal chlorides were condensed and leached with water to convert the iron chloride impurity to iron oxide, the remaining metal chlorides were separated by liquid ion exchange. The metal values were recovered by electrolyzing the metal chloride fractions. Technical papers were presented during 1973 on heat-resisting alloys, magnetic materials, tool and wear-resistant steels and alloys, other alloys, metallic films and coatings, nonmetallic uses, unalloyed cobalt and cobalt compounds, cobalt alloy systems and phases, and analytic procedures.[8]

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[7] Roorda, H. J., and P. E. Queneau. Recovery of Nickel and Cobalt From Limonite by Aqueous Chlorination in Sea Water. Institution of Mining and Metallurgy (Section C), v. 182, No. 799, June 1973, pp. C79–C87.

[8] Cobalt. Battelle Memorial Inst., Cobalt Information Center, Columbus, Ohio, Nos. 1–4, 1973.

Coke and Coal Chemicals

By Eugene T. Sheridan [1]

Production of coal coke in the United States in 1973 was 6% greater than output in 1972. Most of the increase resulted from a greater demand for coke for use in iron blast furnaces. Also contributing to the increase was a larger demand for foundry coke. However, shipments of coke to other industrial plants declined significantly in 1973.

Production remained relatively stable throughout the year and averaged 5.4 million tons per month. The average daily output for all plants ranged from a low of 173,000 tons in July to a high of 179,000 tons in June. Average daily output for the year averaged 176,000 tons.

Except for August, monthly demand for coke exceeded production and producers month-end stocks of oven coke were 60% lower at the end of the year than when the year began. Stocks on hand at oven-coke plants at the end of 1973 were equivalent to a 7-day production at the December rate of output.

Blast furnaces continued to use the bulk of the Nation's coke production, receiving 92% of the 66.4 million tons of coke distributed by producers. However, consumption of coke per ton of hot metal produced at blast furnaces decreased because of a significant increase in the quantities of fuel oil, tar, and pitch used as supplemental fuels in blast furnaces.

Breeze production increased 15%, mainly because more coal was carbonized. Breeze is unsuitable for most metallurgical applications because of its small size and high ash content, the larger part of the breeze production is used by producers for sintering iron ores and for other industrial purposes. However, 44% of the 1973 output was sold, mainly for use as a reductant in the electric furnace processing of phosphate rock to elemental phosphorus. Sales of breeze in 1973 remained at about the 1972 level.

The average delivered value of coals carbonized increased 16% in 1973 and averaged $18.24 per ton. This increase was reflected directly in average coke prices which increased 6% to $42.92 per ton. The largest price increases were made in coke sold to foundries. Foundry coke prices, which averaged $54.73 per ton, f.o.b. plant, were 7% higher than in 1972.

Production of light oil and coke-oven gas increased, principally, because more coal was carbonized. However, output of both tar and ammonia declined.

Foreign trade was relatively small with coke exports of 1.4 million tons comprising only 2% of the production. The bulk of the exported coke was shipped to Canada and West Germany. Coke imports increased significantly in 1973, but exports exceeded imports by 317,000 tons.

The total value of all coals carbonized was $1,716 million, and the total value of all products of carbonization was $2,931 million. The combined value of coke and breeze, the principal products, accounted for 88% of the total value of all products.

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Table 1.—Salient coke statistics

	1969	1970	1971	1972	1973
United States:					
Production:					
Oven coke ----thousand short tons--	64,047	65,654	56,664	59,853	63,496
Beehive coke -----------------do----	710	871	772	654	829
Total ----------------------do----	64,757	66,525	57,436	60,507	64,325
Exports --------------------------do----	1,629	2,478	1,509	1,232	1,395
Imports --------------------------do----	173	153	174	185	1,078
Producers' stocks, Dec. 31 ---------do----	3,120	4,113	3,510	2,941	1,184
Consumption, apparent ------------do----	66,166	63,207	56,689	r 60,046	65,765
Value of coal-chemical materials used or sold -------------thousands--	$288,963	$293,464	$260,171	r $294,905	$355,667
Value of coke and breeze used or sold -------------------thousands--	$1,402,716	$1,899,116	$1,848,781	r $2,080,074	$2,575,150
Total value of all products used or sold [1] ---------------thousands--	$1,691,679	$2,192,580	$2,108,953	r $2,374,979	$2,930,817
World production:					
Hard coke --------thousand short tons--	370,205	386,308	r 377,744	r 381,315	401,849
Gashouse and low-temperature coke -------------------------do----	30,738	28,415	r 24,183	r 21,671	20,787

r Revised.
[1] Data may not add to totals shown because of independent rounding.

COKE AND BREEZE

DOMESTIC PRODUCTION

A substantial increase in pig iron and ferroalloys output in 1973 was accompanied by increased demand for blast-furnace coke and domestic coke production rose 6%. Output was stable throughout the year with monthly production varying between 5.0 million and 5.5 million tons, with the largest amount produced in May. Daily production for the year averaged 176,000 tons, up 7% from the average daily output of 1972.

Ninety-two percent of the oven coke in 1973 was produced at furnace plants. These plants, owned by or financially affiliated with iron and steel companies, are operated mainly to produce coke for use in blast furnaces. The remaining oven coke was produced by merchant plants. This is the segment of the coke industry that produces various grades of coke for sale on the open market. There were 48 furnace plants and 14 merchant plants in operation throughout the year.

Coke was produced in 19 States in 1973. The relative amounts of coke produced in the various States have changed little in the past decade, except that Connecticut and Massachusetts have ceased to be producing States and production was discontinued in New Jersey in 1971. Because coke is used principally for blast furnace fuel, the coke industry is concentrated in the major steel-producing areas of the Eastern and North Central States. The bulk of the 1973 coke output was produced in 12 States east of the Mississippi River. Six States west of the Mississippi River produced coke.

Pennsylvania, the largest producer, accounted for 26% of the output and was followed by Ohio, Indiana, and Alabama in the order named. The combined output of these four States was 63% of the national total.

An average of 1,367 pounds of coke was produced for each ton of coal carbonized in the United States in 1973. The 1973 yield of coke from coal, which averaged 68.35%, has remained fairly constant during the past decade.

Breeze is the term applied to the small sizes of coke that result from screening. Although there is no designated size, breeze refers generally to coke that passes through a ½-inch screen. Coke producers consumed 58% of the breeze produced in 1973, principally as a fuel in agglomerating plants. The remainder was sold, mainly for use as a fuel for smelting phosphate rock to produce elemental phosphorus. The amount of breeze sold has increased significantly in recent years and, in 1973, nearly one-half of the quantity produced was sold.

The breeze yield varies according to operating practices and the quality of the coals carbonized. The lowest yield, 3.7% was recorded for Pennsylvania, while the yield for Illinois averaged 7.2%. The national average yield of 5.3% in 1973 has not varied significantly during the past decade.

An average of 105.6 pounds of breeze was produced for each ton of coal carbonized at oven-coke plants in 1973. Breeze yields at beehive-coke plants were substantially higher than those at oven plants, but beehive breeze production was negligible because only a few plants had recovery facilities.

CONSUMPTION AND SALES

Apparent consumption of coke in the United States in 1973 totaled 65.8 million tons. This quantity (domestic production plus imports, minus exports and changes in stocks) was nearly 6 million tons more than that consumed in 1972 and the increase was attributed principally to greater demand for blast-furnace coke, caused by a 12-million-ton increase in blast-furnace pig iron and ferroalloys production.

Blast-furnace coke rates continued to decline and the amount of coke required to produce 1 ton of blast-furnace output decreased from 1,222 pounds in 1972 to 1,200 pounds in 1973. The net effect of this reduction is that the blast-furnace coke requirement of 60.7 million tons in 1973 would have been 1.1 million tons larger if the coke rate had remained at the 1972 level.

Although a variety of operating practices affect blast-furnace coke rates, the pronounced reduction in the 1973 coke rate resulted mainly from a substantial increase in the quantities of supplemental fuels and oxygen consumed over those used in 1972. The principal fuels used in blast furnaces to reduce coke consumption in 1973 were fuel oil; tar and pitch; and natural, coke oven, and blast furnace gas. Although the units of measurement differ, and the quantity of each fuel used varied greatly, the total calorific value of all supplemental fuels consumed in blast furnaces in 1973 was equivalent to approximately 11 million tons of coke. Oxygen consumption in blast furnaces, which increased 35% in 1973, further reduced blast-furnace coke requirements by making available more sensible heat for the reduction of iron ore to pig iron.

A total of 66.4 million tons of oven and beehive coke was sold and used for all purposes, of which 90% was oven coke supplied by furnace plants. The bulk of this coke was retained by producers for use in their own blast furnaces. Furnace plants sold about 2 million tons of coke—30% of the total coke sold commercially. Fifty-seven percent of the furnace-plant sales was shipped to other blast-furnace plants.

Merchant plants distributed 5.6 million tons of coke in 1973, 96% of which was sold on the open market. Principal markets were blast-furnace operations without coke facilities, independent gray-iron foundries, nonferrous smelters, and chemical plants. A few merchant plants operated coke ovens to supply their own requirements; about 4% of the merchant coke distributed was used by producers. This coke was used principally in chemical plants and affiliated foundries.

One percent of the coke distributed was supplied by beehive plants. The bulk of the beehive coke also was sold to blast-furnace plants.

All States except Alaska, Hawaii, and Nevada received shipments of coke in 1973. Alabama, Illinois, Indiana, Maryland, Michigan, New York, Ohio, Pennsylvania, and West Virginia, which are the major iron- and steel-producing States, received 89% of the total distributed.

The bulk of the coke distributed was blast-furnace coke that was consumed within the producing State, as most blast furnaces are integrated with coke ovens. A few companies shipped coke to affiliated blast furnaces in other States.

About 5% of the coke distributed was shipped to foundries. The chief recipients of foundry coke were the automotive, farm-machinery, machine-tool, heavy-machinery, railroad, and electrical-equipment industries. Most of these industries are concentrated in the East and Midwest. In 1973, the combined consumption of Alabama, Illinois, Iowa, Indiana, Michigan, New Jersey, New York, Ohio, Pennsylvania, Virginia and Wisconsin accounted for more than four-fifths of the foundry-coke shipments. Foundry coke also was consumed in 35 other States.

Coke used for miscellaneous applications was widely distributed, with 41 States receiving shipments of other industrial coke. The principal consumers were nonferrous smelters, alkali plants, and plants that manufacture calcium carbide and elemental phosphorus. Alabama, Idaho, Indiana, Michigan, Ohio, and Pennsylvania received the largest quantities of other industrial coke.

Minor quantities of coke were used for residential heating. This market, which in past years received as much as 10 million tons of coke annually, is virtually nonexistent at this time.

STOCKS

Yearend stocks of coke decreased 60% as the quantity of coke distributed exceeded production by about 2 million tons. Oven-coke plants ended the year with an average 7-day supply at the December rate of production. Normally, beehive plants do not stock coke.

The bulk of the stock was at furnace plants, which had roughly a 7-day supply compared with a 4.3-day supply at merchant plants. There were no producers' stocks of beehive coke at the end of 1973.

Stocks of coke breeze at producers' plants decreased 12% during 1973. Roughly, three-fourths of the breeze on hand was at furnace plants.

VALUE AND PRICE

Coke prices increased again during 1973; the average value of receipts for all grades of oven coke reached $42.92 per ton, and beehive coke averaged $27.31 per ton. The 1973 values represented increases of 5% for oven coke and 24% for beehive coke.

All grades of coke increased in price. An increase of 7% raised the average price of foundry coke to $54.73 per ton, while blast-furnace coke prices were increased an average of 6% to $32.41 per ton. Coke used for other industrial purposes increased, on the average, only slightly in price.

The large variance in the price of blast-furnace and foundry oven coke was attributed principally to lower recovery yields for foundry coke and to its superior properties, which make it a more valuable product. The differences in the average values of oven and beehive coke were due largely to additional transportation costs of coal delivered to oven-coke plants.

FOREIGN TRADE

There was a continuing demand for U.S. coke in foreign markets and exports increased 13% to 1.4 million tons. The bulk of the increase resulted from substantially larger shipments to Canada and West Germany.

Canada remained the principal foreign market, receiving nearly three-quarters of a million tons, 54% of the foreign shipments. Other countries receiving substantial amounts of U.S. coke were West Germany, Mexico, and the Netherlands. Although coke was shipped to more than 21 countries in 1973, the above countries, with Canada, received seven-eighths of the total exports.

The bulk of the coke exported was shipped from the Baltimore, Buffalo, Detroit, Laredo, Norfolk, and Philadelphia customs districts. However, coke was exported through at least 15 other ports.

Because of shortages of domestic coke in certain areas, imports increased nearly six times and totaled 1.1 million tons. This was the largest quantity of coke imported in a single year to date. About two-thirds of the imported coke came from West Germany, and most of the remainder, from Canada.

COKING COALS

QUANTITY AND VALUE OF COAL CARBONIZED

A total of 93.6 million tons of bituminous coal was carbonized at high temperatures for the production of coke in 1973. This quantity was 16% of the 1973 bituminous coal output of the United States, and coke production was the second largest coal market. In addition to bituminous coal 467,000 tons of anthracite was used in coking-coal blends. Anthracite was used principally in the production of foundry coke to achieve greater size and density, properties that are desirable in coke used for the smelting of iron in foundry cupolas.

The delivered average value of all coal carbonized by oven-coke plants in 1973 was $18.32 per ton, and the value of that carbonized by beehive-coke plants averaged $12.42 per ton. The difference in value was attributed mainly to transportation charges for coal shipped to oven-coke plants, as all beehive plants are located at or near the source of the coal they consume. In some instances, transportation costs exceed the value of the coal at the mine; this partially accounts for the high value of the coal consumed in some States.

The average value per ton of coal consumed for coke production at both oven- and beehive-coke plants was 17% greater than in 1972. Coals delivered to some States, however, had increases in average value per ton ranging up to 22%. The highest coal prices were recorded for Maryland and New York where the delivered value of coals used for coke production by all plants averaged $22.59 per ton.

An overall average of 1.46 tons of coal, valued at $26.75, was required for each ton of oven coke produced in 1973. Beehive ovens required an average of 1.58 tons of coal per ton of coke output, but coal costs averaged only $19.62 per ton because of the lower unit value of the coals charged.

BLENDING

Blending of coals is standard practice at oven-coke plants because individual coals do not possess all of the properties required for the production of high-quality coke. In general, blending is used to improve the chemical and physical properties of coke, to control the pressure developed during carbonization, to regulate the yield of products, and to broaden the use of lower-quality coals which could not be used alone for metallurgical-grade coke production. Standard oven-coke operating practice is based upon the use of relatively small proportions of low-volatile coals and high percentages of high-volatile coals. High-volatile coals are not used alone because they produce low yields and weak coke. Low-volatile coals, when added to high-volatile coals improve the yield and the physical properties of the coke. However, the proportions of low-volatile coals used must be restricted because they are highly expanding and, if used alone or in large proportions, would damage oven walls when coke was discharged. Some plants add medium-volatile coals or other materials such as anthracite or coal-tar pitch to their high- and low-volatile coals. Additions of medium-volatile coals can regulate the volatile matter in a mix to the desired content, while anthracite and pitch impart strength, size, and density to the coke.

Blending also permits the use of some high-sulfur coals which are otherwise unsuitable for coke production. Such coals can be blended with low-sulfur coals to the extent that the coal mix contains no more total sulfur than that contained in the coals normally used for producing high-quality coke.

The overall proportions of high-, medium-, and low-volatile coals used in coke mixes has varied little in the past decade, but there are wide variations in the proportions of the different types used by individual plants. West Virginia plants and those in the Western States used the largest percentages of high-volatile coals in their blends, while plants in Minnesota and Wisconsin used relatively high percentages of low-volatile coal. Compared with furnace plants, merchant plants used larger percentages of low-volatile coal because this type produces strong foundry coke, which is produced mainly by merchant plants.

SOURCES

Of the 23 States that produced bituminous coal in 1973, only 13 produced coal that was shipped to coke plants. Of this number, only 10 can be considered suppliers of coking coals as the combined shipments of 3 States were less than one-fourth million tons.

Of the coals received by oven-coke plants, 35% was produced in West Virginia and 27% in Pennsylvania. West Virginia shipments were principally low-volatile coals from McDowell, Wyoming, and Raleigh Counties; medium-volatile coals from McDowell and Nicholas Counties; and high-volatile coals from Boone, Fayette, Kanawha, Logan, Mingo and Nicholas Counties. Pennsylvania supplied mainly high-volatile coals from Allegheny, Green, and Washington Counties and low-volatile coals from Cambria and Somerset Counties. Pennsylvania and West Virginia coals were widely distributed and used in most of the coke producing States.

Kentucky, which supplied 15% of the shipments to coke plants, was another major supplier. All Kentucky coal shipped to coke plants was high-volatile coal produced mainly in Floyd, Harlan, Letcher, and Pike Counties.

Illinois produced high-volatile coking coals, mainly in Franklin and Jefferson Counties; other States with substantial production were Alabama, Colorado, Utah and Virginia. Most of the coal produced in these States was used within the State. Colorado and Utah, however, supplied most of the coals that were carbonized in California.

CAPTIVE COAL

More than one-half of the coal received by oven-coke plants was produced by company-owned or affiliated mines. This captive coal, ordinarily, does not move in commercial channels. Iron and steel producing companies own the bulk of the captive mines and, in 1973, 57% of the coal received by furnace plants was captive. Some merchant plants also own coal mines, but only 24% of the coal they received in 1973 was their own production.

STOCKS

Stocks of bituminous coal at oven-coke plants, remained fairly constant throughout the year, ranging from an average supply of 24 to 35 days at each plant. Bituminous stocks reached their highest yearly level during May when month-end quantities totaled 8.8 million tons. The lowest level, 6.1 million tons, was reported at the end of July.

Because of market competition for low-sulfur coals during the latter part of 1973, bituminous coal stocks at the end of 1973 were 24% lower than when the year began. The 7 million tons on hand at all plants on December 31, 1973, was equivalent to an average supply on hand at each plant of 27 days at the December 1973 rate of consumption.

Only small quantities of anthracite are stocked. Stocks at the end of 1973 totaled only 97,000 tons.

COAL CHEMICALS

The term "coal chemicals" refers to the materials recovered from the volatile matter released from coal during carbonization. Normally, three basic materials—ammonia, tar, and light oil—are recovered at oven-coke plants through a series of complex condensation and absorption processes. The remaining material, which is rich in hydrogen and methane, is called coke-oven gas. Except for ammonia, which is recovered as an aqueous solution or converted to a salt and sold as produced, the basic materials are, in most instances, further processed to yield a number of primary organic chemicals or chemical mixtures of which the most important are benzene, toluene, xylene, solvent naphtha, crude chemical oil, and pitch. Although most oven-coke plants in the United States are equipped to process tar and light oil, the extent to which individual plants produce the various products depends upon economic conditions and the general size of the plant, as yields of the various chemicals are relatively low.

Yields of chemicals vary with the kind of coals carbonized, carbonizing temperatures, and operating techniques and equipment, but approximately 315 pounds of coke-oven gas, 90 pounds of tar, 20 pounds of light oil, and 5 pounds of ammonia are recovered for each ton of coal carbonized. In standard units of measure these quantities amount to about 10,500 cubic feet of coke-oven gas, 10 gallons of tar, and 3 gallons of light oil. Ammonia is recovered as ammonium sulfate at most operations, and the yield per ton of coal presently averages about 16½ pounds.

In terms of calorific value, the products, excluding coke, recovered by oven-coke plants in 1973 totaled 567 trillion Btu's. This quantity was equivalent, roughly, to about one-fourth of the heating value of the coals carbonized.

COKE-OVEN GAS

Coke-oven gas has a relatively high calorific value and producers use most of it as fuel for heating coke ovens and other steel- and allied-plant furnaces. Small quantities are also sold for distribution through city mains and for other industrial use.

Gas yields vary but the quantity of gas produced for each ton of coal carbonized in all slot ovens in 1973 was 10,720 cubic feet. This was slightly more than the yield of 10,570 cubic feet recorded for 1972. However, total gas production increased 9% because about 6 million more tons of coal was carbonized in 1973.

Thirty-nine percent of the coke-oven gas produced in 1973 was used for heating coke ovens. Gas used otherwise, called surplus gas, was used by producers to fire boilers, transferred to steel or allied plants to heat open-hearth and other metallurgical furnaces, sold for industrial use, or distributed through city mains. A small part of the production was wasted because storage facilities at most plants are limited, and the gas was burned in the atmosphere when production exceeded demand.

Coke-oven gas was the principal fuel used for heating coking ovens in 1973 but some operators used blast-furnace gas, a mixture of coke-oven and blast-furnace gas, or natural gas for underfiring. A total of 428 billion cubic feet of coke-oven gas equivalent was so consumed, of which approximately 90% was coke-oven gas.

Surplus coke-oven gas used and sold in 1973 was valued at $190 million, a 32% increase above the 1972 value. No value was reported by producers for coke-oven gas used to heat coke ovens, but applying the average value of $0.319 per thousand cubic feet reported for surplus gas to the gas used for underfiring, the total value of all coke-oven gas used and sold in 1973 would be $312 million. This amount is equivalent to nearly one-fifth of the total value of the coal carbonized at oven-coke plants.

COKE-OVEN AMMONIA

Coal carbonized at high temperatures releases nitrogen which forms ammonia. Ammonia must be removed from the gas prior to processing and coke plant operators normally recover ammonia as an aqueous solution, or as ammonium sulfate or phosphate. However, 13 plants did not recover ammonia as a salable product in 1973.

Production of ammonia decreased 3%, mainly because of a lower yield but, also, because the number of recovery plants decreased by two. The average value per ton of both ammonium sulfate and ammonia liquor increased, however, as did the total value of sales. Ammonia products sold in 1973 represented 5% of the total value of all coal-chemicals sales.

COAL TAR AND DERIVATIVES

All oven-coke plants produced tar but yields varied and ranged generally between 6 and 9 gallons per ton of coal carbonized. High-volatile coals normally evolve a larger percentage of tar and California, Colorado, and Utah—States that used large percentages of high-volatile coals—had the highest tar yields.

Despite the substantial increase in the quantity of coal carbonized at oven-coke plants, tar production decreased slightly because of the lower yield in 1973. Both merchant and furnace plants had lower yields and also lower production.

Coke-plant operators consumed 53% of the tar produced. Of this quantity, 58% was processed (refined or "topped") while 42% underwent no processing and was burned for fuel. The remaining tar was sold, principally to tar-distilling plants which refine tar to produce a variety of derivatives.

Most of the coke plants that processed tar in 1973 partially refined the tar in a process called "topping." In this method, the low-boiling distillate fraction, consisting mainly of tar acids, bases, and naphthalenes, was separated from the crude tar. The residue, called soft pitch, was, in most instances, burned for fuel. Furnace plants in particular benefit from this method of operation since they can sell the distillate and retain the pitch for use as fuel. This reduces the amount of other fuels that they must normally purchase. However, the relative quantities of tar topped and burned, as well as the quantities sold, depend upon a number of economic factors, such as the availability and current market prices of tar, tar distillates, and other substitute fuels. Most of the merchant plant tar production was sold because these plants have no use for the pitch, which makes up the bulk of the products they recover through topping.

The majority of the plants that processed tar recovered only crude chemical oil and a residual tar, or soft pitch. However, some of the larger plants recovered a number of tar derivatives, including creosote oil, cresylic acid, cresols, naphthalene, phenol, pyridine, and medium and hard pitch. Statistics on some of these products could not be shown in this report, but the data were transmitted to the U.S. Tariff Commission, which publishes them along with similar data from tar distillers and petroleum refiners in monthly and annual reports on synthetic organic chemicals.

CRUDE LIGHT OIL AND DERIVATIVES

Light oil is a liquid that contains a number of aromatic hydrocarbons that are extracted from the gas after tar, ammonia, and in some instances, naphthalene have been removed. Crude tar also contains a small amount of light oil, but this usually is not recovered at coke plants. Virtually all light oil produced at coke plants is recovered by an absorption process in which the gas is sprayed with a higher boiling petroleum oil as the gas stream is channeled through absorption towers. After light oil is recovered, it is separated from the absorption oil by direct steam distillation. Approximately 3 gallons of light oil, equal to about 1% of the weight of the coal, is recovered for each ton of coal carbonized. Yields vary with the kind of coals carbonized and with operating conditions but an average of 2.63 gallons of light oil was recovered at plants that extracted light oil in 1973. Most plants recovered light oil, but some found it uneconomical to remove the light oil and left it in the gas to be burned as fuel. Yields per ton of coal decreased at both merchant and furnace plants in 1973.

Producers sold 45% of their crude light oil output. The large increase in light oil sales in recent years is attributed principally to the inability of some plants to produce derivatives that meet the more rigid specifications established for these products. Such plants sell light oil to petroleum-refining companies which process it along with petroleum fractions into benzene, toluene, and a number of other chemical intermediates.

As with other coal-chemical materials, yields of products derived from light oil vary, but approximately seven-eighths of the light oil processed is recovered as salable products. Of the light-oil processed by coke plants in 1973, 61% was recovered as benzene; 11% as toluene; 3% as xylene; and the remainder, as other products.

Ninety-six percent of the benzene production was specification grades. In past years, large amounts of motor-grade benzene was produced for use in gasoline to increase anti-knock properties but present petroleum refining techniques have all but eliminated this use for benzene.

The unit value of all light oil derivatives sold in 1973 ranged from $0.17 per gallon for other industrial-grade benzene to $0.267 per gallon for specification-grade benzene. The average value of all light oil products sold increased 26% to $0.255 per gallon.

WORLD REVIEW

World production of metallurgical coke in 1973 was estimated at 402 million short tons. This quantity was 5% higher than the 1972 output and the increase was attributed largely to production gains in Japan, the United States, and the U.S.S.R.

Europe, with 55% of the total, led in world production. European output was 2% greater than in 1972, mainly because of larger output in the U.S.S.R. Asia, with eight producing countries, ranked second in output while North America, with only three producing countries, ranked third.

The Soviet Union, with nearly one-fourth of the world output, was the largest producer of coke. Soviet production increased 2% over that of 1972 and the estimated 90 million tons of coke and breeze produced in 1973 was a record output for the country. Metallurgical coke production, however, probably totaled about 85 million tons as an estimated 5 million tons of e production was breeze.

The United States, with 16% of the world total, ranked second in production, and Japan, with 13%, ranked third. The United States had a 6% production increase, but Japan's output was 21% above the level recorded in 1972.

Other leading coke-producing countries in order of output were West Germany, the People's Republic of China, the United Kingdom, and Poland. The production of these countries combined with that of the U.S.S.R., the United States, and Japan accounted for more than three-quarters of the world production.

In addition to the metallurgical-grade coke, which is produced at high-temperatures in conventional slot- and beehive-coke ovens, there was 11 million tons of other coke that was produced at high, medium, and low temperatures in vertical and horizontal retorts and other types of carbonizing equipment. Commonly referred to as "gashouse" or "soft" coke, this material is not suitable for most metallurgical applications but is used principally for domestic heating, chemical processing, and gas production. Production of "gashouse" coke has been declining in recent years and the 1973 world output was only about one-fourth as large as a decade ago.

TECHNOLOGY

Developmental work at coke plants continued to be focused upon systems for the reduction of atmospheric pollution. In some instances, success has been realized; however, no device or combination of devices has proved totally effective.[2]

Current energy shortages and dislocations, as well as more stringent requirements for improved air quality at coke plants, has prompted new interest in the dry quenching of coke. This technique, developed after World War I in Switzerland, features a completely enclosed system that employs an inert gas which serves as a cooling and heat transfer medium. Quenching by this method also imparts a number of desirable physical properties to coke. Test results have revealed that dry quenched coke has a higher heating value, a higher strength and greater stability. Moreover, the unit furnishes a return on the initial investment. This system, which features pollution control along with energy recovery, has been employed in the U.S.S.R. since the early 1960's.[3]

The effects of oven door leakage have also become the focal point of much concern. A technique has been refined that employs a system of vertical and horizontal chimneys within the lining of the oven door which has helped to alleviate oven-gas pressure and leakage around sealing rings. Although the idea is not new, the technology and methods have been tuned to a point that renders these modifications feasible. Prior to success, the strength of the oven door was compromised because of the innovations. Also, the diameter of the chimneys was such that difficulty was encountered in keeping them clear of coal and char. However, with the above measures initiated, oven-gas pressure taken near the floor of the oven was reduced from 140 millimeters of water to levels in the range of 30 millimeters.

Many attempts have been made to control pollution which occurs during the charging of coke ovens and one method that has been successful is staged sequential charging. This operating practice limits the exposure of the free openings and simultaneously maintains a positive draft on the openings, thus, curtailing smoke emissions. Unlike other approaches to the charging problem, this "system" does not employ any exotic equipment. In essence, the problem of smoke emissions is managed by the charging of one or two portals and closing them before the charging occurs from the other coal hoppers.[4 5]

The Calgon Corp. has developed a new method for the treatment of coke plant effluents. This is a sequential process that consists of chemical clarification of waste water for the removal of solids; adsorption with granular activated carbon for the removal of dissolved organics; and catalyic oxidation for the removal of cyanide. In the clarification step, suspended materials are removed and the pH of the water is adjusted so that an optimum adsorption rate can be achieved in the next step. Then, by means of activated carbon, dissolved organic chemicals are removed from the water after which free cyanide is removed by catalyic oxidation of the cyanide on granular carbon.[6]

In an effort to neutralize predicted future shortages of natural gas, heavy oil, and more important, metallurgical grade coal, the Japanese have developed a technology for producing a cheap reducing gas by reforming some of the hydrocarbons contained in blast-furnace top gas with carbon dioxide and water from the reforming raw material. The top gas of a blast furnace is thus reformed to a reducing gas which can be injected into the furnace stack and used in conjunction with other supplemental fuels. Introduced on a pilot scale, the Japanese were able to reduce the coke rate in an experimental furnace to less than 700 pounds per net ton of hot metal.[7]

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[2] Battelle Memorial Institute (Columbus, Ohio). Summary Report on Control of Coke-Oven Emissions to the American Iron and Steel Institute. Dec. 31, 1973, pp. 1–88.

[3] Kemmetmueller, R. Dry Coke Quenching—Proved, Profitable, Pollution-Free. Iron and Steel Engineer, v. 50, October 1973, pp. 71–77.

[4] Work cited in footnote 2.

[5] Edgar, W. D. Coke-Oven Air Emission Abatement. Iron and Steel Engineer, v. 49, October 1972, pp. 86–94.

[6] Van Stone, R. G. Treatment of Coke Plant Waste Effluent. Iron and Steel Engineer, v. 49, April 1972, pp. 63–66.

[7] Iron and Steel Engineer. Reducing Gas Production Process. V. 50, September 1973, p. 137.

Table 2.—Statistical summary of the coke industry in the United States in 1973

	Slot ovens	Beehive ovens	Total
Coke produced:			
At merchant plants thousand short tons	5,271	[1]	[1]
At furnace plants [2] do	58,225	[1]	[1]
Total [3] do	63,496	829	64,325
Breeze produced do	4,902	W	4,902
Coal carbonized:			
Bituminous:			
Thousand short tons	92,338	1,310	93,648
Value (thousands)	$1,693,082	$16,270	$1,709,352
Average per ton	$18.34	$12.42	$18.25
Anthracite:			
Thousand short tons	467	--	467
Value (thousands)	$7,175	--	$7,175
Average per ton	$15.36	--	$15.36
Total coal carbonized: [3]			
Thousand short tons	92,806	1,310	94,116
Value (thousands)	$1,700,119	$16,270	$1,716,389
Average per ton	$18.32	$12.42	$18.24
Average yield in percent of total coal carbonized:			
Coke	68.42	63.28	68.35
Breeze (at plants actually recovering)	5.28	W	5.28
Coke used by producing companies:			
In blast furnaces:			
Thousand short tons	57,360	--	57,360
Value (thousands)	$2,146,153	--	$2,146,153
In foundries:			
Thousand short tons	371	--	371
Value (thousands)	$19,326	--	$19,326
For other industrial uses:			
Thousand short tons	239	--	239
Value (thousands)	$8,391	--	$8,391
Breeze used by producing companies:			
In steam plants:			
Thousand short tons	234	--	234
Value (thousands)	$1,943	--	$1,943
In agglomerating plants:			
Thousand short tons	1,689	--	1,689
Value (thousands)	$19,842	--	$19,842
For other industrial uses:			
Thousand short tons	917	--	917
Value (thousands)	$8,581	--	$8,581
Coke sold (commercial sales):			
To blast furnaces:			
Thousand short tons	3,036	829	3,865
Value (thousands)	$98,398	$22,665	$121,063
Average per ton	$32.41	$27.31	$31.32
To foundries:			
Thousand short tons	3,349	--	3,349
Value (thousands)	$183,337	--	$183,337
Average per ton	$54.73	--	$54.73
To other industrial plants:			
Thousand short tons	1,204	[4]	1,204
Value (thousands)	$44,010	[4]	$44,010
Average per ton	$36.55	[4]	$36.55
For residential heating:			
Thousand short tons	[5]	--	[5]
Value (thousands)	[5]	--	[5]
Average per ton	[5]	--	[5]
Breeze sold (commercial sales):			
Thousand short tons	2,165	W	2,165
Value (thousands)	$22,505	W	$22,505
Average per ton	$10.39	W	$10.39
Coal-chemical materials produced:			
Crude tar:			
Thousand gallons	732,455	--	732,455
Gallons per ton of coal	7.89	--	7.89
Ammonia: [6]			
Thousand short tons	628	--	628
Pounds per ton of coal	16.41	--	16.41
Crude light oil:			
Thousand gallons	226,109	--	226,109
Gallons per ton of coal	2.63	--	2.63
Gas:			
Million cubic feet	994,916	--	994,916
Thousand cubic feet per ton of coal	10.72	--	10.72
Percent burned in coking process	38.51	--	38.51
Percent surplus used or sold	59.90	--	59.90
Percent wasted	1.59	--	1.59

See footnotes at end of table.

Table 2.—Statistical summary of the coke industry in the United States in 1973—Continued

	Slot ovens	Beehive ovens	Total
Value of coal-chemical materials used or sold:			
Crude tar and derivatives:			
Used ---------- thousands--	$53,082	--	$53,082
Sold ---------- do----	$56,678	--	$56,678
Ammonia products [7] ---------- do----	$16,419	--	$16,419
Crude light oil and derivatives [8] ---------- do----	$39,464	--	$39,464
Surplus gas ---------- do----	$190,024	--	$190,024

W Withheld to avoid disclosing individual company confidential data.
1 Not separately recorded.
2 Plants associated with iron-blast furnaces.
3 Data may not add to totals shown because of independent rounding.
4 Included with beehive coke sold "to blast furnaces" to avoid disclosing individual company data.
5 Included with "To other industrial plants" to avoid disclosing individual company data.
6 In terms of sulfate equivalent.
7 Includes ammonium sulfate, ammonia liquor (NH_3 content), and diammonium phosphate.
8 Includes intermediate light oil.

Table 3.—Summary of oven-coke operations in the United States in 1973, by State

State	Plants in existence Dec. 31	Coal carbonized (thousand short tons)	Yield of coke from coal (percent)	Coke produced (thousand short tons)
Alabama	7	7,280	70.49	5,132
California, Colorado, Utah	3	5,384	62.89	3,386
Maryland and New York	4	10,304	68.61	7,070
Illinois	4	3,108	62.45	1,941
Indiana	6	14,042	66.48	9,335
Kentucky, Missouri, Tennessee, Texas	5	2,858	67.74	1,936
Michigan	3	5,297	73.08	3,871
Minnesota and Wisconsin	3	1,194	70.69	844
Ohio	12	13,751	68.64	9,438
Pennsylvania	12	24,108	69.31	16,710
West Virginia	3	5,480	69.93	3,832
Total 1973	62	92,806	68.42	[1] 63,496
At merchant plants	14	7,334	71.87	5,271
At furnace plants	48	85,471	68.12	58,225
Total 1972	62	86,687	69.05	59,853

1 Data does not add to total shown because of independent rounding.

Table 4.—Summary of beehive-coke operations in the United States in 1973, by State

State	Plants in existence Dec. 31	Coal carbonized (thousand short tons)	Yield of coke from coal (percent)	Coke produced (thousand short tons)
Pennsylvania and Virginia	5	1,310	63.28	829
Total 1973	5	1,310	63.28	829
Total 1972	6	1,059	61.76	654

Table 5.—Production of oven and beehive coke in the United States, by month

(Thousand short tons)

Month	1972 Total [1]	1972 Daily average [2]	1973 Total [1]	1973 Daily average [2]
OVEN COKE				
January	4,763	154	5,364	173
February	4,651	160	4,891	175
March	5,076	164	5,356	173
April	5,091	170	5,262	175
May	5,237	169	5,454	176
June	4,976	166	5,325	177
July	5,024	162	5,307	171
August	5,088	164	5,383	174
September	4,822	161	5,153	172
October	5,026	162	5,358	173
November	4,914	164	5,218	174
December	5,183	167	5,426	175
Total [1]	59,853	164	63,496	174
BEEHIVE COKE				
January	49	2	63	2
February	53	2	62	2
March	51	2	65	2
April	55	2	64	2
May	51	2	66	2
June	53	2	60	2
July	49	2	64	2
August	54	2	71	2
September	54	2	67	2
October	53	2	83	3
November	62	2	81	3
December	70	2	82	3
Total [1]	654	2	829	2
TOTAL				
January	4,812	155	5,427	175
February	4,704	162	4,953	177
March	5,127	165	5,421	175
April	5,146	172	5,326	178
May	5,287	171	5,520	178
June	5,029	168	5,382	179
July	5,073	164	5,371	173
August	5,142	166	5,454	176
September	4,877	163	5,220	174
October	5,079	164	5,441	176
November	4,976	166	5,299	177
December	5,253	169	5,508	178
Total [1]	60,507	165	64,325	176

[1] Data may not add to totals shown because of independent rounding.
[2] Daily average calculated by dividing monthly production by number of days in month.

Table 6.—Production of oven coke in the United States, by type of plant

(Thousand short tons)

Month	1972 Merchant plants	1972 Furnace plants	1973 Merchant plants	1973 Furnace plants
PRODUCTION				
January	482	4,281	460	4,904
February	460	4,191	407	4,484
March	490	4,586	456	4,900
April	467	4,625	434	4,827
May	486	4,751	434	5,019
June	468	4,508	432	4,893
July	467	4,558	438	4,869
August	463	4,626	435	4,948
September	453	4,369	438	4,715
October	473	4,553	448	4,910
November	462	4,452	435	4,783
December	455	4,728	455	4,972
Total [1]	5,626	54,228	5,271	58,225
DAILY AVERAGE				
January	16	138	15	158
February	16	145	15	160
March	16	184	15	158
April	16	154	14	161
May	16	153	14	162
June	16	150	14	163
July	15	147	14	157
August	15	149	14	160
September	15	146	15	157
October	15	147	14	158
November	15	148	14	159
December	15	153	15	160
Average for year	15	148	14	160

[1] Data may not add to totals shown because of independent rounding.

Table 7.—Production of oven coke and number of plants in the United States, by type of plant

Year	Number of active plants [1]		Coke produced (thousand short tons)		Percent of production	
	Merchant plants	Furnace plants [2]	Merchant plants	Furnace plants	Merchant plants	Furnace plants
1969	[3] 16	49	5,919	58,129	9.2	90.8
1970	[3] 16	49	5,915	59,739	9.0	91.0
1971	16	49	5,567	51,097	9.8	90.2
1972	14	49	5,626	54,228	9.4	90.6
1973	14	49	5,271	58,225	8.3	91.7

[1] Includes plants operating any part of year.
[2] Includes one tar-refining plant.
[3] Includes one light oil refining plant.

Table 8.—Production of coke in the United States, by State

(Thousand short tons)

State	1972	1973
OVEN COKE		
Alabama	5,355	5,132
California, Colorado, Utah	2,955	3,386
Illinois	2,085	1,941
Indiana	9,191	9,335
Kentucky, Missouri, Tennessee, Texas	2,099	1,936
Maryland and New York	5,435	7,070
Michigan	3,677	3,871
Minnesota and Wisconsin	818	844
Ohio	8,860	9,438
Pennsylvania	15,869	16,710
West Virginia	3,510	3,832
Total [1]	59,853	63,496
BEEHIVE COKE		
Pennsylvania	654	829
Virginia	(2)	(2)
Total	654	829
Grand total	60,507	64,325

[1] Data may not add to totals shown because of independent rounding.
[2] Included with Pennsylvania to avoid disclosing individual company data.

Table 9.—Breeze recovered at coke plants in the United States in 1973, by State

(Thousand short tons and thousand dollars)

State	Yield per ton of coal [1] (percent)	Produced	Used by producers						Sold		On hand Dec. 31
		Quantity	In steam plants		In agglomerating plants		For other Industrial use		Quantity	Value	
			Quantity	Value	Quantity	Value	Quantity	Value			
OVEN COKE											
Alabama	4.78	348	--	--	(2)	(2)	25	358	155	1,976	29
California, Colorado, Utah	4.35	236	--	--	153	1,807	23	260	(2)	(2)	72
Illinois	7.18	223	(2)	(2)	(2)	(2)	14	127	83	761	30
Indiana	6.60	921	--	--	(2)	(2)	168	1,523	371	3,714	174
Kentucky, Missouri, Tennessee, Texas	6.09	174	(2)	(2)	--	--	81	883	92	1,249	38
Maryland and New York	6.23	642	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	183
Michigan	5.19	275	--	--	--	--	(2)	(2)	(2)	(2)	42
Minnesota, Wisconsin, West Virginia	6.08	406	(2)	(2)	(2)	(2)	94	779	197	1,720	29
Ohio	5.75	791	(2)	(2)	(2)	(2)	221	1,696	563	5,858	50
Pennsylvania	3.67	885	(2)	(2)	412	5,543	176	1,799	252	2,981	91
Undistributed	--	--	234	1,943	1,124	12,490	115	1,155	452	4,246	--
Total 1973 [3]	5.28	4,902	234	1,943	1,689	19,842	917	8,581	2,165	22,505	738
At merchant plants	6.78	497	105	948	249	2,968	166	1,452	245	4,029	185
At furnace plants	5.15	4,404	128	995	1,440	16,873	751	7,128	1,919	18,476	553
Total 1972	4.92	4,261	265	2,396	1,305	16,095	704	6,759	2,113	22,366	r 841
BEEHIVE COKE											
Pennsylvania and Virginia:											
Total 1973	W	W	--	--	--	--	--	--	W	W	--
Total 1972	W	W	--	--	--	--	--	--	W	W	--

r Revised. W Withheld to avoid disclosing individual company confidential data.

[1] Calculated by dividing production by coal carbonized at plants actually recovering breeze.

[2] Included with "Undistributed" to avoid disclosing individual company confidential data.

[3] Data may not add to totals shown because of independent rounding.

Table 10.—Oven- and beehive-coke breeze used and sold in the United States, by use

(Thousand short tons)

Year	Used by producers: In steam plants	Used by producers: In agglomerating plants	Used by producers: For other industrial use	Sold	Average value per ton
1969	439	1,650	775	1,538	$8.13
1970	366	1,948	704	[1] 2,067	9.74
1971	309	1,582	650	1,879	10.80
1972	265	1,305	704	[1] 2,113	10.59
1973	234	1,689	917	[1] 2,165	10.39

[1] Does not include beehive-coke breeze sold (to avoid disclosing individual company data).

Table 11.—Apparent consumption of coke in the United States

(Thousand short tons)

Year	Total production	Imports	Exports	Net change in stocks	Apparent consumption [1]	Consumption: In iron furnaces [2]: Quantity	Consumption: In iron furnaces [2]: Percent	Consumption: All other purposes: Quantity	Consumption: All other purposes: Percent
1969	64,757	173	1,629	−2,865	66,166	60,176	90.9	5,990	9.1
1970	66,525	153	2,478	+993	63,207	58,151	92.0	5,056	8.0
1971	57,436	174	1,509	−588	56,689	51,498	90.8	r 5,191	9.2
1972	60,507	185	1,232	−586	r 60,046	54,607	r 90.9	r 5,439	r 9.1
1973	64,325	1,078	1,395	−1,757	65,765	60,720	92.3	5,082	7.7

r Revised.
[1] Production plus imports, minus exports, plus or minus net change in stocks.
[2] American Iron and Steel Institute; figures include coke consumed in manufacturing ferroalloys.

Table 12.—Coke and coking coal consumed per short ton of pig iron, and ferroalloys produced in the United States

Year	Coke per short ton of pig iron and ferroalloys [1] (pounds)	Yield of coke from coal (percent)	Coking coal per short ton of pig iron and ferroalloys (pounds, calculated)
1969	1,260.4	69.4	1,816.1
1970	1,266.6	r 69.0	1,833.0
1971	1,260.8	69.0	1,827.2
1972	1,221.6	r 69.0	r 1,767.9
1973	1,200.0	68.4	1,754.4

r Revised.
[1] American Iron and Steel Institute; consumption for pig iron only, excluding furnaces making ferroalloys, was 1,252 in 1969; 1,260 in 1970; 1,254 in 1971; 1,216.2 in 1972 and 1,193.8 in 1973.

Table 13.—Oven coke produced in the United States, used by producers, and sold in 1973, by State

(Thousand short tons and thousand dollars)

State	Produced	Used by producing companies				Commercial sales	
		In blast furnaces		For other purposes [1]		To blast-furnace plants	
	Quantity	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	5,132	3,191	107,264	193	9,606	962	27,330
California, Colorado, Utah	3,386	3,345	108,681	(2)	(2)	--	--
Illinois	1,941	1,974	73,131	(2)	(2)	(2)	(2)
Indiana	9,335	9,067	345,179	(2)	(2)	(2)	(2)
Kentucky, Missouri, Tennessee, Texas	1,936	(2)	(2)	(2)	(2)	(2)	(2)
Maryland and New York	7,070	6,745	274,468	(2)	(2)	(2)	(2)
Michigan	3,871	(2)	(2)	(2)	(2)	(2)	(2)
Minnesota, West Virginia, Wisconsin	4,677	4,228	159,887	(2)	(2)	(2)	(2)
Ohio	9,438	8,296	301,333	81	2,833	768	26,710
Pennsylvania	16,710	16,386	625,232	65	2,959	(2)	(2)
Undistributed	--	4,128	150,978	271	12,319	1,306	44,358
Total 1973	63,496	57,360	2,146,153	610	27,717	3,036	98,398
At merchant plants	5,271	(3)	13	213	9,548	1,764	59,854
At furnace plants	58,225	57,360	2,146,140	397	18,170	1,272	38,544
Total 1972	59,853	52,738	1,705,269	681	27,699	2,613	80,053

State	Commercial sales—Continued					
	To foundries		To other industrial plants [4]		Total [5]	
	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	748	40,005	241	10,373	1,951	77,708
California, Colorado, Utah	(2)	(2)	(2)	(2)	(2)	(2)
Illinois	--	--	--	--	(2)	(2)
Indiana	(2)	(2)	100	2,832	(2)	(2)
Kentucky, Missouri, Tennessee, Texas	(2)	(2)	(2)	(2)	(2)	(2)
Maryland and New York	(2)	(2)	(2)	(2)	(2)	(2)
Michigan	(2)	(2)	(2)	(2)	(2)	(2)
Minnesota, West Virginia, Wisconsin	402	22,305	141	5,091	559	27,922
Ohio	(2)	(2)	(2)	(2)	1,230	50,141
Pennsylvania	552	30,049	(2)	(2)	945	44,247
Undistributed	1,647	90,978	722	25,714	2,904	125,727
Total 1973	3,349	183,337	1,204	44,010	7,589	325,745
At merchant plants	2,922	161,216	653	25,723	5,338	246,793
At furnace plants	427	22,121	551	18,287	2,251	78,952
Total 1972	3,057	156,387	r 1,326	48,303	6,996	r 284,744

r Revised.
[1] Comprises 371,000 tons valued at $19,326,000 used in foundries; 239,000 tons valued at $8,391,000 for other purposes.
[2] Included with "Undistributed" to avoid disclosing individual company data.
[3] Less than ½ unit.
[4] Includes coke used "For residential heating."
[5] Data may not add to totals shown because of independent rounding.

Table 14.—Production and sales of beehive coke in the United States in 1973

(Thousand short tons and thousand dollars)

State	Produced	Commercial sales									
		To blast-furnace plants		To foundries		To other industrial plants		For residential heating		Total	
	Quantity	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Pennsylvania and Virginia	829	829	22,665	--	--	(1)	(1)	--	--	829	22,665
Total 1973	829	829	22,665	--	--	(1)	(1)	--	--	829	22,665
Total 1972	654	669	14,745	--	--	(1)	(1)	--	--	669	14,745

[1] Included with beehive coke sold "To blast-furnace plants" to avoid disclosing individual company data.

Table 15.—Distribution of oven and beehive coke and breeze in 1973 [1]

(Thousand short tons)

Consuming State	Coke				Breeze
	To blast-furnace plants	To foundries	To other industrial plants [2]	Total [3]	
Alabama	2,738	355	67	3,160	338
Arizona	--	10	4	14	--
Arkansas	--	2	3	5	--
California	1,438	35	30	1,503	74
Colorado	715	8	24	747	58
Connecticut	--	10	--	10	--
Delaware	--	--	(4)	(4)	(4)
Florida	--	2	23	25	14
Georgia	--	12	5	17	1
Idaho	--	(4)	124	124	--
Illinois	3,610	204	28	3,843	241
Indiana	9,827	201	83	10,111	882
Iowa	--	106	1	107	--
Kansas	--	13	1	14	--
Kentucky	1,286	41	36	1,363	134
Louisiana	--	37	26	63	1
Maine	--	1	--	1	--
Maryland	3,312	19	2	3,332	297
Massachusetts	--	30	(4)	30	--
Michigan	4,679	810	43	5,531	236
Minnesota	2	19	28	49	108
Mississippi	--	1	1	2	6
Missouri	--	25	39	65	26
Montana	--	(4)	38	38	(4)
Nebraska	--	2	10	12	(4)
New Hampshire	--	1	--	1	--
New Jersey	(4)	79	44	122	36
New Mexico	--	--	1	1	--
New York	3,530	128	38	3,696	386
North Carolina	(4)	13	7	21	9
North Dakota	--	1	3	4	--
Ohio	10,758	546	215	11,519	678
Oklahoma	--	4	1	5	(4)
Oregon	--	1	19	20	(4)
Pennsylvania	13,895	295	250	14,441	825
Rhode Island	--	1	--	1	--
South Carolina	--	7	50	57	11
South Dakota	--	1	--	1	--
Tennessee	32	74	36	143	91
Texas	878	108	41	1,026	82
Utah	1,208	22	12	1,241	46
Vermont	--	1	--	1	--
Virginia	--	95	3	98	143
Washington	--	3	6	9	--
West Virginia	3,305	68	28	3,401	205
Wisconsin	--	172	5	177	37
Wyoming	--	--	6	6	--
Total [3]	61,213	3,561	1,380	66,154	4,962
Exported	10	158	65	233	44
Grand total	61,223	3,719	1,445	66,387	5,006

[1] Based upon reports from producers showing destination and principle end use of coke used and sold. Does not include imported coke which totaled 1,078,000 tons in 1973.
[2] Includes coke used "For residential heating."
[3] Data may not add to totals shown because of independent rounding.
[4] Less than ½ unit.

Table 16.—Producers' stocks of coke and breeze in the United States on Dec. 31, 1973, by State

(Thousand short tons)

State	Coke: Blast furnace	Coke: Foundry	Coke: Residential heating and other	Coke: Total[1]	Breeze
Oven coke:					
Alabama	101	3	(2)	105	29
California, Colorado, Utah	100	--	--	100	72
Illinois	50	--	--	50	30
Indiana	142	1	(2)	144	174
Kentucky, Missouri, Tennessee, Texas	21	1	8	30	38
Maryland and New York	154	1	--	154	183
Michigan	72	1	1	74	42
Minnesota and Wisconsin	3	1	1	5	28
Ohio	188	10	2	200	50
Pennsylvania	182	33	28	243	91
West Virginia	80	--	--	80	(2)
Total 1973[1]	1,093	50	41	1,184	738
At merchant plants	2	38	25	65	185
At furnace plants	1,091	12	17	1,120	553
Total 1972	2,690	137	113	2,941	r 841

r Revised.
1 Data may not add to totals shown because of independent rounding.
2 Less than ½ unit.

Table 17.—Producers' month-end stocks of oven coke in the United States

(Thousand short tons)

Month	At merchant plants 1972	At merchant plants 1973	At furnace plants 1972	At furnace plants 1973	Total[1] 1972	Total[1] 1973
January	148	326	3,437	2,497	3,585	2,824
February	158	291	3,454	2,269	3,611	2,560
March	184	252	3,139	2,039	3,323	2,291
April	211	206	2,900	1,829	3,111	2,035
May	227	159	2,795	1,638	3,022	1,796
June	263	139	2,643	1,572	2,907	1,712
July	340	148	2,748	1,367	3,089	1,514
August	355	150	2,831	1,370	3,185	1,520
September	384	126	2,818	1,375	3,202	1,501
October	360	96	2,729	1,339	3,089	1,435
November	349	76	2,662	1,236	3,011	1,313
December	351	71	2,590	1,113	2,941	1,184

1 Data may not add to totals shown because of independent rounding.

Table 18.—Average receipts per short ton of coke sold (commercial sales) in the United States, by use

Year	To blast-furnace plants	To foundries	To other industrial plants	For residential heating	Total
OVEN COKE					
1969	$19.14	$35.29	$18.25	$18.67	$24.50
1970	25.05	40.83	22.74	20.19	29.97
1971	30.49	47.98	29.75	21.46	37.41
1972	30.64	51.16	r 36.43	(1)	40.70
1973	32.41	54.73	36.55	(1)	42.92
BEEHIVE COKE					
1969	16.31	6.84	15.93	16.52	16.23
1970	19.77	18.98	23.01	--	19.89
1971	21.24	--	W	--	21.45
1972	22.01	--	W	--	22.04
1973	27.31	--	W	--	27.31

r Revised. W Withheld to avoid disclosing individual company confidential data.
1 Included with "To other industrial plants."

Table 19.—Coke exported from the United States, by country and customs district

	1971		1972		1973	
	Quantity (Short tons)	Value (Thousands)	Quantity (Short tons)	Value (Thousands)	Quantity (Short tons)	Value (Thousands)
COUNTRY						
Algeria	40,678	$692	--	--	191	$14
Argentina	6,680	300	--	--	--	--
Belgium-Luxembourg	27,983	320	34,041	$608	84,714	1,723
Brazil	37,801	1,630	11,775	699	8,465	537
Bulgaria	29,126	1,774	--	--	--	--
Canada	492,391	16,289	488,006	14,996	747,543	18,210
Dominican Republic	210	5	448	11	373	9
Germany, West	85,411	1,402	141,021	1,989	265,084	5,270
India	271	12	614	26	1,123	55
Iran	688	51	68	4	184	15
Italy	34,524	414	7,652	106	--	--
Japan	138,496	2,210	88,236	1,412	32,338	611
Liberia	11,810	187	--	--	--	--
Mexico	80,248	2,831	105,181	4,049	102,284	3,874
Netherlands	151,081	1,628	129,654	1,172	104,845	1,728
Norway	19,397	366	8,471	215	8,019	140
Panama	(1)	1	--	--	755	21
Peru	90,714	3,888	1,383	86	141	15
Portugal	52,028	2,090	--	--	--	--
Romania	28,043	1,357	57,950	1,313	--	--
Singapore	--	--	805	25	52	2
South Africa, Republic of	(1)	(1)	160	3	759	16
Spain	--	--	106,839	1,683	23,821	405
Sweden	--	--	169	4	5,480	135
United Kingdom	23,244	263	3,704	229	838	75
Venezuela	119,014	6,039	32,174	1,664	543	22
Yugoslavia	37,579	998	12,270	383	6,527	237
Other	1,222	72	1,012	43	901	24
Total	1,508,639	44,819	1,231,633	30,720	1,394,980	33,138
CUSTOMS DISTRICT						
Baltimore	199,103	5,333	127,156	2,572	107,709	2,609
Buffalo	295,761	9,191	230,965	8,796	424,922	11,236
Chicago	7,569	65	64,037	753	78,190	635
Cleveland	67,714	565	133,412	1,051	10,052	111
Detroit	243,407	6,287	189,723	4,683	188,367	4,510
Duluth	2,028	91	14,163	185	65,022	773
El Paso	30	1	158	8	188	3
Great Falls	859	18	170	9	701	13
Houston	1,191	27	2,047	93	1,420	101
Laredo	79,084	2,781	96,899	3,852	100,856	3,829
Los Angeles	50	3	53,054	588	20,349	226
Miami	394	13	367	7	--	--
Mobile	291,529	7,970	146,551	3,235	42,056	938
New Orleans	1,517	70	5,050	297	41,459	1,067
New York City	214	7	580	20	378	10
Nogales	401	22	514	24	821	26
Norfolk	121,618	4,347	53,650	887	122,222	1,954
Ogdensburg	17,455	518	3,312	77	2,282	59
Pembina	17,164	815	16,563	875	17,332	933
Philadelphia	154,556	6,388	81,667	2,357	164,885	3,794
Portland, Maine	241	4	--	--	--	--
St. Albans	160	6	--	--	--	--
San Diego	733	28	948	31	522	17
San Francisco	(1)	1	6,744	136	--	--
Seattle	5,818	255	3,882	183	5,208	292
Other	43	13	21	1	39	2
Total	1,508,639	44,819	1,231,633	30,720	1,394,980	33,138

[1] Less than ½ unit.

Table 20.—U.S. imports for consumption of coke by country and customs district

	1971		1972		1973	
	Quantity (Short tons)	Value (Thousands)	Quantity (Short tons)	Value (Thousands)	Quantity (Short tons)	Value (Thousands)
COUNTRY						
Australia	--	--	--	--	123	$2
Canada	170,784	$4,593	171,297	$4,276	289,618	9,099
Czechoslovakia	--	--	--	--	11,574	355
Germany, West	3,036	444	268	42	732,084	27,969
Hungary	--	--	--	--	3,190	108
Italy	--	--	--	--	31,945	1,271
South Africa, Republic of	94	1	13,457	331	--	--
United Kingdom	--	--	1	(1)	9,203	459
Total	173,914	5,038	185,023	4,649	1,077,737	39,263
CUSTOMS DISTRICT						
Baltimore	--	--	--	--	225,368	9,749
Boston	--	--	1	(1)	--	--
Buffalo	967	25	3,110	66	45,746	1,543
Charleston	--	--	13,457	331	--	--
Chicago	11,498	339	20,276	730	76,045	2,795
Cleveland	--	--	25,768	298	--	--
Detroit	88,835	2,471	21,437	342	134,937	4,592
Duluth	330	3	--	--	--	--
Great Falls	69,022	1,749	100,187	2,814	102,754	2,885
Honolulu	110	7	165	11	165	13
New Orleans	3,031	439	103	31	94,932	3,576
Ogdensburg	--	--	229	13	2,352	128
Pembina	58	1	--	--	--	--
Philadelphia	--	--	--	--	384,966	13,454
Portland, Maine	33	1	34	1	--	--
St. Albans	15	(1)	256	12	10,472	528
San Juan	15	3	--	--	--	--
Total	173,914	5,038	185,023	4,649	1,077,737	39,263

[1] Less than ½ unit.

Table 21.—Coke: World production by type and country

(Thousand short tons)

Kind of coke and country [1]	1971	1972	1973 [p]
METALLURGICAL COKE [2]			
North America:			
Canada [3] [4]	5,105	5,207	5,919
Mexico	[r] 1,650	1,913	2,132
United States	57,436	60,507	64,325
South America:			
Argentina [3] [e]	397	397	397
Brazil	1,483	1,841	1,973
Chile	345	340	[e] 340
Colombia	513	578	[e] 650
Peru	37	[e] 12	[e] 12
Europe:			
Austria [3]	1,806	1,836	1,894
Belgium	7,477	7,980	8,608
Czechoslovakia	11,543	11,770	[e] 11,800
Finland [4]	123	95	74
France [3]	13,784	12,723	[e] 13,000
Germany, East	2,553	1,769	[e] 1,500
Germany, West	41,379	37,977	37,475
Greece	193	295	309
Hungary	862	856	[e] 860
Italy	7,668	7,744	8,457
Netherlands [3]	2,094	2,198	2,927
Norway	363	342	[e] 350
Poland	15,631	17,502	[e] 18,000
Romania	1,221	1,250	[e] 1,179
Spain	[5] 4,482	[5] 4,900	[e] 5,000
Sweden [3] [4]	550	713	[e] 550
U.S.S.R.[3]	86,340	87,909	[e] 90,000
United Kingdom	21,066	18,967	19,622
Yugoslavia [3]	[r] 1,433	1,430	[e] 1,400
Africa:			
Egypt, Arab Republic of	[r] [e] 386	390	[e] 391
Rhodesia, Southern [e]	270	270	270
South Africa, Republic of	3,959	3,950	[e] 3,970

See footnotes at end of table.

Table 21.—Coke: World production by type and country—Continued

(Thousand short tons)

Kind of coke and country [1]	1971	1972	1973 p
Asia:			
China, People's Republic of e	r 24,000	r 26,500	28,700
India [6]	9,893	10,132	e 8,860
Iran [7]	63	e 66	69
Japan [3]	r 42,676	41,898	50,858
Korea, North e	2,400	2,400	2,400
Korea, Republic of	--	--	356
Taiwan	280	274	240
Turkey	1,420	r e 1,400	1,579
Oceania:			
Australia	4,856	4,980	e 5,400
New Zealand	e 7	4	e 3
Total metallurgical coke	r 377,744	381,315	401,849
GASHOUSE COKE [8]			
South America:			
Brazil	90	49	e 55
Uruguay	17	15	15
Europe:			
Czechoslovakia	13	e 13	e 13
Denmark	149	e 125	e 180
France	4	e 4	e 4
Germany, West	2,220	1,894	1,705
Greece	15	e 15	e 15
Hungary	417	400	e 400
Italy	125	51	285
Poland	1,466	r e 1,500	e 1,500
Spain	8	5	e 7
Sweden [9]	409	r e 130	e 170
Switzerland	115	100	e 110
United Kingdom	1,056	251	206
Africa:			
Egypt, Arab Republic of e	33	33	33
South Africa, Republic of	111	111	109
Asia:			
India	88	e 88	e 75
Japan [3]	5,283	4,873	5,197
Sri Lanka	9	8	e 8
Taiwan	9	1	(10)
Turkey e	r 110	r 110	110
Oceania:			
Australia e	772	772	772
New Zealand [11]	e 40	24	30
Total gashouse coke	r 12,559	10,572	10,999
ALL OTHER TYPES [12]			
Europe:			
Czechoslovakia	891	475	e 440
Germany, East [13]	6,806	6,225	e 6,100
Romania	15	e 15	e 15
Asia:			
India	3,852	4,314	e 1,140
Japan	--	--	2,013
Turkey e	r 60	r 70	80
Total all other types	r 11,624	11,099	9,788
Grand total	r 401,927	402,986	422,636

e Estimate. p Preliminary. r Revised.

1 In addition to the countries listed, Algeria, Malaysia, People's Republic of China, Mexico, Norway, Romania, and the U.S.S.R. have produced gashouse coke in previous years and may have continued production during the time period covered by this table. However, no official statistics are available and information is inadequate to make reliable estimates of production levels. Except where otherwise noted, coke breeze has been excluded from this table.

2 Coke produced at high temperature in conventional carbonizing equipment (including slot and beehive coke ovens).

3 Includes breeze.

4 Includes relatively small amounts of gas coke.

5 Includes relatively small amounts of low-temperature coke.

6 Data are total of so-called hard coke production from collieries and coke plants (including those at steelworks).

7 Data are for years beginning March 21 of that stated.

8 Includes coke produced at high temperatures in carbonizing equipment designed primarily for gas manufacture (horizontal and vertical coal-gas retorts). In addition to the countries listed, Canada and Finland produce gas coke. However, this figure is not reported separately and has been included with metallurgical coke.

9 Excludes small quantities of gashouse coke which are included with metallurgical coke.

10 Less than ½ unit.

11 Data are for years beginning March 31 of that stated.

12 Includes coke produced at low and medium temperatures, as well as that produced in unconventional equipment (chain-grate cokers).

13 Includes coke produced from lignite at high temperatures.

Table 22.—Quantity and value at ovens of coal carbonized in the United States in 1973, by State

State	Coal carbonized			Coal per ton of coke	
	Thousand short tons	Value		Short tons	Value
		Total (thousands)	Average		
OVEN COKE					
Alabama	7,280	$125,460	$17.24	1.41	$24.31
California, Colorado, Utah	5,384	87,544	16.26	1.59	25.85
Illinois	3,108	50,177	16.14	1.60	25.82
Indiana	14,042	258,249	18.39	1.50	27.59
Kentucky, Missouri, Tennessee, Texas	2,858	50,611	17.71	1.48	26.21
Maryland and New York	10,304	232,784	22.59	1.46	32.98
Michigan	5,297	112,845	21.30	1.37	29.18
Minnesota and Wisconsin	1,194	25,420	21.29	1.41	30.02
Ohio	13,751	241,533	17.56	1.46	25.63
Pennsylvania	24,108	432,725	17.95	1.44	25.85
West Virginia	5,480	82,772	15.10	1.43	21.59
Total 1973[1]	92,806	1,700,119	18.32	1.46	26.75
At merchant plants	7,334	144,995	19.77	1.39	27.48
At furnace plants	85,471	1,555,125	18.19	1.47	26.74
Total 1972	86,687	1,363,945	15.74	1.45	22.81
BEEHIVE COKE					
Pennsylvania and Virginia	1,310	16,270	12.42	1.58	19.62
Total:					
1973	1,310	16,270	12.42	1.58	19.62
1972	1,059	10,428	9.85	1.62	15.96

[1] Data may not add to totals shown because of independent rounding.

Table 23.—Bituminous coal carbonized in coke ovens in the United States, by month

(Thousand short tons)

Month	1972			1973		
	Slot	Beehive	Total	Slot	Beehive	Total
January	6,790	82	6,872	7,718	102	7,820
February	6,689	86	6,775	7,118	99	7,217
March	7,373	85	7,458	7,847	103	7,950
April	7,338	85	7,423	7,625	102	7,727
May	7,557	82	7,639	7,942	106	8,048
June	7,126	84	7,210	7,678	94	7,772
July	7,276	79	7,355	7,854	101	7,955
August	7,273	87	7,360	7,781	113	7,894
September	6,952	88	7,040	7,497	105	7,602
October	7,258	87	7,345	7,755	132	7,887
November	7,063	102	7,165	7,612	124	7,736
December	7,518	112	7,630	7,909	127	8,036
Total[1]	86,213	1,059	87,272	92,338	1,310	93,648

[1] Data may not add to totals shown because of independent rounding.

Table 24.—Anthracite carbonized at oven-coke plants in the United States, by month

(Thousand short tons)

Month	1972	1973
January	40	45
February	42	38
March	42	42
April	38	36
May	37	37
June	41	41
July	36	36
August	37	38
September	38	36
October	40	34
November	41	43
December	42	43
Total	474	[1] 467

[1]Data does not add to total shown because of independent rounding.

Table 25.—Average value per short ton of coal carbonized at oven-coke plants in the United States, by State

State	1972	1973
Alabama	$14.16	$17.24
California, Colorado, Utah	13.82	16.26
Illinois	14.94	16.14
Indiana	15.73	18.39
Kentucky, Missouri, Tennessee, Texas	15.28	17.71
Maryland and New York	20.52	22.59
Michigan	19.38	21.30
Minnesota and Wisconsin	18.16	21.29
Ohio	15.49	17.56
Pennsylvania	14.88	17.95
West Virginia	13.50	15.10
Average	15.73	18.32
Value of coal per ton of coke	22.81	26.75

Table 26.—Average volatile content of bituminous coal carbonized by oven-coke plants in the United States

(Thousand short tons)

Year	High		Medium		Low		Total	
	Quantity	Volatile content (percent)	Quantity	Volatile content (percent)	Quantity	Volatile content (percent)	Quantity	Volatile content (percent)
1969	59,284	35.1	12,785	26.8	19,674	18.6	91,743	30.4
1970	62,703	34.0	11,660	26.3	20,217	17.2	[1] 94,581	29.4
1971	53,542	35.1	12,085	25.2	15,904	18.3	81,531	30.4
1972	60,536	34.7	8,754	26.4	16,923	16.8	86,213	30.3
1973	64,486	34.6	10,090	26.6	17,762	16.2	92,338	30.2

[1] Data does not add to total shown because of independent rounding.

Table 27.—Coal received by oven-coke plants in the United States in 1973, by consuming State and volatile content [1]

(Thousand short tons)

Consuming State	High-volatile		Medium-volatile		Low-volatile		Total coal receipts
	Quantity	Percent of total	Quantity	Percent of total	Quantity	Percent of total	
Alabama	2,625	34.8	4,406	58.3	524	6.9	7,555
California, Colorado, Utah	4,200	78.6	1,076	20.1	66	1.3	5,342
Illinois	2,420	78.8	--	--	650	21.2	3,071
Indiana	9,429	69.0	1,390	10.2	2,851	20.8	13,672
Kentucky, Missouri, Tennessee, Texas	1,873	67.4	421	15.1	486	17.5	2,780
Maryland and New York	6,416	63.8	663	6.6	2,981	29.6	10,059
Michigan	3,362	68.2	273	5.6	1,293	26.2	4,928
Minnesota and Wisconsin	781	58.8	137	10.3	410	30.9	1,328
Ohio	10,138	76.3	614	4.6	2,528	19.1	13,280
Pennsylvania	15,377	65.8	2,458	10.5	5,536	23.7	23,371
West Virginia	4,402	81.8	--	--	977	18.2	5,379
Total 1973 [2]	61,023	67.2	11,438	12.6	18,301	20.2	90,763
At merchant plants	2,671	39.2	1,900	27.9	2,249	33.0	6,820
At furnace plants	58,352	69.5	9,537	11.4	16,053	19.1	83,944
Total 1972	57,997	65.9	14,468	16.5	15,497	17.6	87,962

[1] Volatile matter on moisture-free basis: High-volatile—over 31%; medium-volatile—22 to 31%; and low-volatile—14 to 22%.
[2] Data may not add to totals shown because of independent rounding.

Table 28.—Origin of coal received by oven-coke plants in the United States in 1973, by producing county and volatile content [1]

(Thousand short tons)

Source of coal	Volatile content: High	Medium	Low	Total [2]
Alabama:				
Bibb	289	--	--	289
Jefferson	1,336	4,205	--	5,541
Walker	406	85	--	491
Arkansas:				
Sebastian	--	--	216	216
Colorado:				
Gunnison	794	--	--	794
Las Animas	624	--	--	624
Pitkin	--	1,000	--	1,000
Illinois:				
Franklin	1,393	--	--	1,393
Jefferson	2,440	--	--	2,440
Saline	85	--	--	85
Kentucky:				
Floyd	1,802	--	--	1,802
Greenup	3	--	--	3
Harlan	4,475	--	--	4,475
Knott	657	--	--	657

See footnotes at end of table.

Table 28.—Origin of coal received by oven-coke plants in the United States in 1973, by producing county and volatile content [1]—Continued

(Thousand short tons)

Source of coal	Volatile content			Total [2]
	High	Medium	Low	
Kentucky—Continued				
Knox	8	--	--	8
Letcher	3,369	--	--	3,369
Perry	13	--	--	13
Pike	3,515	--	--	3,515
Whitely	28	--	--	28
New Mexico:				
Colfax	771	--	--	771
Oklahoma:				
Haskell	7	265	--	270
Rogers	163	--	--	163
Pennsylvania:				
Anthracite	--	--	489	489
Bituminous:				
Allegheny	2,331	--	--	2,331
Blair	--	--	11	11
Cambria	--	396	2,960	3,356
Clearfield	--	16	([3])	16
Fayette	161	--	--	161
Greene	5,932	--	--	5,932
Indiana	--	48	--	48
Somerset	--	208	1,367	1,575
Washington	9,846	--	--	9,846
Westmoreland	736	--	--	736
Tennessee:				
Clairborne	3	--	--	3
Texas:				
Randall	--	--	5	5
Utah:				
Carbon	2,011	--	--	2,011
Virginia:				
Buchanan	22	491	1,487	2,000
Dickenson	341	154	--	495
Russell	233	662	--	896
Tazewell	--	20	--	20
Wise	1,091	--	--	1,091
West Virginia:				
Barbour	298	--	--	298
Boone	2,161	--	--	2,161
Fayette	1,697	713	523	2,933
Gilmer	199	--	--	199
Greenbrier	--	70	--	70
Harrison	--	3	--	3
Kanawha	2,513	--	--	2,513
Logan	5,252	320	--	5,571
McDowell	11	1,480	5,954	7,446
Marion	636	--	--	636
Mercer	--	--	1,053	1,053
Mingo	1,517	35	--	1,552
Morgan	4	--	--	4
Monongalia	99	--	--	99
Nicholas	838	967	--	1,806
Raleigh	128	58	1,542	1,729
Upshur	86	--	--	86
Webster	--	18	--	18
Wyoming	698	225	2,493	3,416
Canada:				
Alberta	--	--	198	198
Ontario	--	--	3	3
Total [2]	61,023	11,438	18,301	90,763

[1] Volatile matter on moisture-free basis: high-volatile—over 31%; medium-volatile—22 to 31%; and low-volatile—14 to 22%.
[2] Data may not add to totals shown because of independent rounding.
[3] Less than ½ unit.

Table 29.—Origin of coal received by oven-coke plants in the United States in 1973, by State

(Thousand short tons)

Consuming State	Producing State: Alabama	Arkansas	Colorado	Illinois	Kentucky	New Mexico	Oklahoma
Alabama	5,980	--	--	--	115	--	--
California, Colorado, Utah	--	66	2,418	--	--	771	76
Illinois	--	150	--	1,150	1,084	--	--
Indiana	265	--	--	2,768	3,554	--	--
Kentucky Missouri, Tennessee, Texas	68	--	--	--	--	--	357
Maryland and New York	--	--	--	--	2,168	--	--
Michigan	--	--	--	--	1,664	--	--
Minnesota and Wisconsin	--	--	--	--	386	--	--
Ohio	8	--	--	--	2,020	--	1
Pennsylvania	--	--	--	(1)	2,317	--	--
West Virginia	--	--	--	--	572	--	--
Total 1973	6,320	216	2,418	3,917	13,870	771	434
At merchant plants	639	--	--	--	209	--	1
At furnace plants	5,682	216	2,418	3,917	13,661	771	433
Total 1972	6,758	115	2,013	3,697	13,480	625	447

Consuming State	Producing State—Continued: Pennsylvania	Utah	Virginia	Tennessee	Texas	West Virginia	Canada	Total [2]
Alabama	127	--	923	--	--	412	--	7,555
California, Colorado, Utah	--	2,011	--	--	--	--	--	5,341
Illinois	53	--	42	--	--	592	--	3,071
Indiana	1,368	--	239	--	--	5,488	--	13,672
Kentucky, Missouri, Tennessee, Texas	151	--	271	--	5	1,928	--	2,780
Maryland and New York	3,611	--	749	--	--	3,340	192	10,059
Michigan	41	--	224	3	--	2,996	--	4,928
Minnesota and Wisconsin	195	--	98	--	--	641	8	1,328
Ohio	4,026	--	779	--	--	6,446	--	13,280
Pennsylvania	12,285	--	1,118	--	--	7,650	--	23,371
West Virginia	2,645	--	61	--	--	2,101	--	5,379
Total 1973	24,502	2,011	4,504	3	5	31,594	200	[2] 90,763
At merchant plants	415	--	1,047	3	5	4,501	--	6,820
At furnace plants	24,087	2,011	3,457	--	--	27,093	200	83,944
Total 1972	23,826	1,872	4,118	--	--	31,009	--	87,962

[1] Less than ½ unit.
[2] Data may not add to totals shown because of independent rounding.

Table 30.—Quantity and percentage of captive coal received by oven-coke plants in the United States

(Thousand short tons)

Year	At merchant plants: Total coal received	Captive coal: Quantity	Captive coal: Percent	At furnace plants: Total coal received	Captive coal: Quantity	Captive coal: Percent	Total: Total coal received	Captive coal: Quantity	Captive coal: Percent
1969	8,232	2,895	35.2	83,416	52,447	62.9	91,648	55,342	60.4
1970	7,866	2,320	29.5	86,869	51,379	59.2	94,735	53,699	56.7
1971	5,284	2,235	42.3	74,113	44,319	59.8	79,397	46,554	58.6
1972	7,804	2,325	29.8	80,158	45,354	56.7	87,962	47,679	54.3
1973	7,052	1,753	24.4	83,722	47,412	56.6	90,774	[1] 49,134	54.1

[1] Day does not add to total shown because of independent rounding.

Table 31.—Month-end stocks of bituminous coal at oven-coke plants in the United States

(Thousand short tons)

Month	1972	1973
January	7,850	8,498
February	8,118	8,381
March	8,560	8,439
April	9,343	8,500
May	10,014	8,821
June	10,138	8,544
July	8,259	6,059
August	8,558	6,493
September	8,777	6,575
October	9,052	7,097
November	9,460	7,171
December	9,032	6,875

Table 32.—Month-end stocks of anthracite at oven-coke plants in the United States

(Thousand short tons)

Month	1972	1973
January	107	80
February	125	62
March	79	46
April	68	45
May	66	53
June	61	52
July	60	54
August	68	60
September	70	66
October	90	78
November	96	97
December	84	97

Table 33.—Coal-chemical materials, exclusive of breeze, produced at oven-coke plants in the United States in 1973 [1]

Product	Produced	Sold: Quantity	Sold: Value: Total (thousands)	Sold: Value: Average per unit	On hand Dec. 31
Tar, crude ....thousand gallons..	732,455	336,342	$41,705	$0.124	50,771
Tar derivatives:					
Sodium phenolate or carbolate ....do....	2,922	2,716	202	.075	138
Crude chemical oil (tar acid oil) ..do....	7,065	7,027	1,999	.171	157
Pitch of tar: [2]					
Soft ....thousand short tons..	218	13	527	40.539	3
Hard ....do....	307	203	8,989	43.833	4
Other tar derivatives [3]	XX	XX	4,146	XX	XX
Ammonia products:					
Sulfate ....thousand short tons..	600	616	16,009	25.989	32
Liquor (NH_3 content) ....do....	7	8	410	51.250	1
Diammonium phosphate ....do....	(4)	(4)	(4)	(4)	(4)
Total ....do....	XX	XX	16,419	XX	XX
Sulfate equivalent of all forms ...do....	628	646	XX	XX	36
NH_3 equivalent of all forms .....do....	162	167	XX	XX	9
Gas:					
Used under boilers, etc. million cubic feet..	[5] 994,916	98,919	31,340	.316	--
Used in steel or allied plants .....do....		471,714	151,313	.321	--
Distributed through city mains ....do....		12,135	4,519	.372	--
Sold for industrial use ....do....		13,149	2,852	.217	--
Total ....do....	[5] 994,916	[6] 595,918	190,024	.319	--
Crude light oil ....thousand gallons..	[7] 226,109	93,819	13,183	.141	9,054
Light oil derivatives:					
Benzene:					
Specification grades (1°, 2°, 90%) do....	85,876	76,823	20,504	.267	3,359
Other industrial grades ....do....	3,299	3,165	538	.170	131
Toluene (all grades) ....do....	14,496	14,127	3,160	.224	1,067
Xylene (all grades) ....do....	3,104	3,040	689	.227	274
Solvent naphtha (all grades) ......do....	2,806	2,514	513	.204	214
Other light oil derivatives ....do....	4,297	3,005	777	.259	358
Total ....do....	113,878	[6] 102,673	26,181	.255	5,403
Intermediate light oil ....do....	5,118	1,029	100	.097	161
Grand total	XX	XX	302,584	XX	XX

XX Not applicable.
[1] Includes products of tar distillation conducted by oven-coke operators under the same corporate names.
[2] Soft-water-softening point—less than 110° F; medium—110° to 160° F; hard-oven—160° F. Figures on hard pitch includes small amount of medium-pitch.
[3] Creosote oil, cresols, cresylic acid, naphthalene, phenol, pyridine, refined tar, tar paint.
[4] Included with sulfate to avoid disclosing individual company data.
[5] Includes gas used for heating oven and gas wasted.
[6] Data may not add to totals shown because of independent rounding.
[7] 130,009,000 gallons refined by coke-oven operators to make derived products shown.

Table 34.—Coal equivalent of the thermal materials, except coke, produced at oven-coke plants in the United States

Year	Materials produced				Estimated equivalent in heating value [1] (billion Btu)					Coal equivalent (thousand short tons)
	Coke breeze (thousand short tons)	Surplus gas (billion cubic feet)	Tar (thousand gallons)	Light oil (thousand gallons)	Coke breeze	Surplus gas	Tar	Light oil	Total	
1969	4,401	595	768,766	258,910	88,020	327,250	115,315	33,658	564,243	21,536
1970	4,665	585	760,926	244,107	93,300	321,750	114,139	31,734	560,923	21,409
1971	4,048	507	679,377	201,626	80,960	278,850	101,907	26,211	487,928	18,623
1972	4,261	534	747,186	214,201	85,220	293,700	112,078	27,846	518,844	r 19,803
1973	4,902	599	732,455	226,110	98,040	329,450	109,868	29,394	566,752	21,632

r Revised.
[1] Breeze, 10,000 Btu per pound; gas, 550 Btu per cubic foot; tar, 150,000 Btu per gallon; and light oil, 130,000 Btu per gallon.

Table 35.—Average value of coal-chemical materials used or sold and of coke and breeze per short ton of coal carbonized in the United States

	1969	1970	1971	1972	1973
Ammonia products	$0.173	$0.151	$0.136	r $0.141	$0.177
Light oil and its derivatives	.435	.405	.365	.350	.418
Surplus gas used or sold	1.502	1.561	1.640	1.660	2.052
Tar and its derivatives (including naphthalene):					
Tar burned by producers [1]	.317	.398	.341	.366	.572
Sold	.685	.623	.721	r.720	.611
Total	3.112	3.138	3.203	r 3.237	3.830
Coke produced [2]	12.560	19.208	21.135	22.978	26.315
Breeze produced	.388	.481	.534	.533	.558
Grand total	16.060	22.827	24.872	r 26.748	30.719

r Revised.
[1] Includes pitch-of-tar.
[2] Average value of coke used or sold.

Table 36.—Percentage of coal costs recovered from the recovery of coal-chemical materials in the United States

	1969	1970	1971	1972	1973
Product:					
Ammonia products	1.8	1.3	1.1	1.0	1.0
Light oil and its derivatives	4.4	4.3	3.8	3.2	2.3
Surplus gas used or sold	14.4	12.8	11.7	10.6	11.2
Tar and its derivatives used or sold (including naphthalene)	10.5	9.0	8.0	8.0	6.5
Total	31.1	27.4	24.6	22.8	21.0
Value of coal per short ton	$10.42	$12.21	$14.00	$15.74	$18.32

Table 37.—Production and disposal of coke-oven gas in the United States in 1973, by State

(Million cubic feet)

State	Produced		Used in heating ovens	Surplus used or sold			Wasted
	Total	Thousand cubic feet per ton of coal		Quantity	Value		
					Thousands	Average per thousand cubic feet	
Alabama	70,894	9.74	33,778	35,079	$8,341	$0.238	2,037
California, Colorado, Utah	70,079	13.02	21,144	48,782	15,498	.318	153
Illinois	31,841	20.24	12,888	17,755	4,407	.248	1,148
Indiana	152,681	10.87	58,467	93,504	29,495	.315	711
Kentucky, Missouri, Tennessee, Texas	25,951	9.08	13,466	9,814	2,226	.227	2,670
Maryland and New York	109,673	10.64	38,001	69,833	26,524	.380	1,839
Michigan	57,312	10.82	11,938	43,314	14,456	.334	2,060
Minnesota and Wisconsin	12,606	10.56	6,081	6,019	2,449	.407	506
Ohio	145,767	10.60	54,977	87,765	26,704	.304	3,074
Pennsylvania	254,749	10.57	112,611	140,687	45,346	.322	1,450
West Virginia	63,363	11.56	19,813	43,365	14,578	.336	186
Total 1973 [1]	994,916	10.72	383,163	595,918	190,024	.319	15,835
At merchant plants	65,557	8.94	31,772	28,562	7,175	.251	5,223
At furnace plants	929,360	10.87	351,391	567,356	182,848	.322	10,612
Total 1972	916,011	10.57	361,887	534,491	143,893	.269	19,632

[1] Data may not add to totals shown because of independent rounding.

Table 38.—Surplus coke-oven gas used by producers in the United States and sold in 1973, by State

State	Used by producers					
	Under boilers, etc.			In steel or allied plants		
	Quantity	Value		Quantity	Value	
		Thousands	Average per thousand cubic feet		Thousands	Average per thousand cubic feet
Alabama	11,647	$2,534	$0.218	19,692	$4,928	$0.250
California, Colorado, Utah	(1)	(1)	(1)	(1)	(1)	(1)
Illinois	3,896	823	.211	13,374	3,501	.262
Indiana	15,342	5,196	.339	75,183	22,868	.304
Kentucky, Missouri, Tennessee, Texas	5,733	1,424	.248	(1)	(1)	(1)
Maryland and New York	954	302	.317	62,608	23,924	.382
Michigan	(1)	(1)	(1)	(1)	(1)	(1)
Minnesota and Wisconsin	(1)	(1)	(1)	(1)	(1)	(1)
Ohio	9,330	2,858	.303	73,609	22,486	.306
Pennsylvania	10,650	2,836	.266	128,380	42,207	.329
West Virginia	(1)	(1)	(1)	(1)	(1)	(1)
Undistributed	41,368	15,366	.371	98,869	31,400	.318
Total 1973 [2]	98,919	31,340	.316	471,714	151,313	.321
At merchant plants	11,517	2,575	.224	(3)	(3)	(3)
At furnace plants	87,402	28,765	.329	471,714	151,313	.321
Total 1972	102,360	27,241	.266	364,896	101,307	.278

See footnotes at end of table.

Table 38.—Surplus coke-oven gas used by producers in the United States and sold in 1973, by State—Continued

State	Sold					
	Distributed through city mains			For industrial use		
	Quantity	Value: Thousands	Value: Average per thousand cubic feet	Quantity	Value: Thousands	Value: Average per thousand cubic feet
Alabama	--	--	--	(1)	(1)	(1)
California, Colorado, Utah	--	--	--	--	--	--
Illinois	--	--	--	(1)	(1)	(1)
Indiana	(1)	(1)	(1)	--	--	--
Kentucky, Missouri, Tennessee, Texas	--	--	--	(1)	(1)	(1)
Maryland and New York	(1)	(1)	(1)	(1)	(1)	(1)
Michigan	--	--	--	(1)	(1)	(1)
Minnesota and Wisconsin	--	--	--	(1)	(1)	(1)
Ohio	(1)	(1)	(1)	(1)	(1)	(1)
Pennsylvania	(1)	(1)	(1)	(1)	(1)	(1)
West Virginia	--	--	--	(1)	(1)	(1)
Undistributed	12,135	$4,519	$0.372	13,149	$2,852	$0.217
Total 1973 [2]	12,135	4,519	.372	13,149	2,852	.217
At merchant plants	(3)	(3)	(3)	11,113	2,395	.216
At furnace plants	12,135	4,519	.372	2,036	457	.224
Total 1972	11,392	3,947	.347	55,843	11,397	.204

[1] Included with "Undistributed" to avoid disclosing individual company confidential data.
[2] Data may not add to totals shown because of independent rounding.
[3] Included with furnace plants to avoid disclosing individual company confidential data.

Table 39.—Coke-oven gas and other gases used in heating coke ovens in the United States in 1973, by State [1]

(Million cubic feet)

State	Coke-oven gas	Blast-furnace gas	Natural gas	Total coke-oven gas equivalent
Alabama	33,778	--	--	33,778
California, Colorado, Utah	21,144	--	45	21,189
Illinois	12,888	1,650	--	14,538
Indiana	58,467	5,664	2,065	66,196
Kentucky, Missouri, Tennessee, Texas	13,466	--	--	13,466
Maryland and New York	38,001	9,999	521	48,521
Michigan	11,938	12,636	--	24,574
Minnesota and Wisconsin	6,081	--	22	6,103
Ohio	54,977	4,106	--	59,083
Pennsylvania	112,611	1,569	--	114,180
West Virginia	19,813	6,122	--	25,935
Total 1973 [2]	383,163	41,746	2,654	427,563
At merchant plants	31,772	--	22	31,794
At furnace plants	351,391	41,746	2,632	395,769
Total 1972	361,887	31,377	3,322	396,586

[1] Adjusted to an equivalent of 550 Btu per cubic foot.
[2] Data may not add to totals shown because of independent rounding.

Table 40.—Coke-oven ammonia produced in the United States and sold in 1973, by State

(Thousand short tons and thousand dollars)

State	Active plants [1]	Produced			
		Sulfate equivalent	Pounds per ton of coal coked	As sulfate [2]	As liquor (NH_3 content)
Alabama	7	67	18.41	67	--
California, Colorado, Utah	3	33	12.26	30	(3)
Illinois	4	23	14.80	23	--
Indiana and Michigan	6	124	14.96	119	(3)
Kentucky, Minnesota, Tennessee, Texas	4	17	13.46	10	(3)
Maryland and New York	4	101	19.60	99	(3)
Ohio	10	104	16.28	94	(3)
Pennsylvania	8	118	18.16	118	--
West Virginia	3	41	14.96	41	--
Undistributed	--	--	--	--	7
Total 1973 [4]	49	628	16.41	600	7
At merchant plants	4	37	16.80	(5)	7
At furnace plants	45	591	16.39	600	(6)
Total 1972	51	r 650	r 18.76	r 599	13

State	Sold				On hand Dec. 31	
	As sulfate		As liquor (NH_3 content)		As sulfate	As liquor (NH_3 content)
	Quantity	Value	Quantity	Value		
Alabama	67	1,220	--	--	3	--
California, Colorado, Utah	30	777	(3)	(3)	1	(3)
Illinois	25	524	--	--	2	--
Indiana and Michigan	91	4,371	(3)	(3)	6	(3)
Kentucky, Minnesota, Tennessee, Texas	10	192	(3)	(3)	1	(3)
Maryland and New York	108	2,713	(3)	(3)	1	(3)
Ohio	108	2,376	(3)	(3)	6	(3)
Pennsylvania	134	3,086	(3)	(3)	11	(3)
West Virginia	44	749	--	--	1	--
Undistributed	--	--	8	410	--	1
Total 1973 [4]	616	16,009	8	410	32	1
At merchant plants	(5)	(5)	8	410	32	1
At furnace plants	616	16,009	(6)	(6)	(6)	(6)
Total 1972	r 504	r 11,622	13	614	84	2

r Revised.
1 Number of plants that recovered ammonia.
2 Includes diammonium phosphate to avoid disclosing individual company data.
3 Included with "Undistributed" to avoid disclosing individual company data.
4 Data may not add to totals shown because of independent rounding.
5 Included with furnace plants to avoid disclosing individual company data.
6 Included with merchant plants to avoid disclosing individual company data.

Table 41.—Coke-oven tar produced in the United States, used by producers, and sold in 1973, by State

(Thousand gallons)

State	Produced		Used by producers		
	Total	Gallons per ton of coal coked	For refining or topping	As fuel	Otherwise
Alabama	49,949	6.86	(1)	(1)	(1)
California, Colorado, Utah	49,519	9.20	(1)	(1)	(1)
Illinois	21,488	6.91	(1)	(1)	(1)
Indiana	101,338	7.22	(1)	24,940	--
Kentucky, Missouri, Tennessee, Texas	18,567	6.50	--	--	(1)
Maryland and New York	81,485	7.91	(1)	--	--
Michigan	37,393	7.06	--	--	--
Minnesota and Wisconsin	7,328	6.14	--	30,645	(1)
Ohio	117,826	8.57	(1)	54,685	--
Pennsylvania	202,762	8.41	(1)	39,485	(1)
West Virginia	44,800	8.18	(1)	--	(1)
Undistributed	--	--	225,801	13,982	925
Total 1973 [2]	732,455	7.89	225,801	163,736	925
At merchant plants	39,875	5.43	(3)	--	--
At furnace plants	692,580	8.10	225,801	163,736	925
Total 1972	r 739,383	r 8.53	r 265,584	119,030	4,286

State	Sold for refining into tar products			On hand Dec. 31
	Quantity	Value: Thousand dollars	Value: Average per gallon	
Alabama	28,119	$3,642	$0.130	2,218
California, Colorado, Utah	30,198	5,328	.176	3,122
Illinois	17,331	1,923	.111	1,505
Indiana	35,469	4,106	.116	3,922
Kentucky, Missouri, Tennessee, Texas	18,600	2,137	.113	606
Maryland and New York	32,413	3,853	.119	6,369
Michigan	38,018	4,161	.109	2,026
Minnesota and Wisconsin	2,449	275	.112	561
Ohio	52,080	6,551	.126	5,375
Pennsylvania	66,299	7,985	.120	21,842
West Virginia	15,365	1,744	.114	3,224
Undistributed	--	--	--	--
Total 1973 [2]	336,342	41,705	.124	50,771
At merchant plants	39,579	4,559	.115	1,280
At furnace plants	296,763	37,146	.125	49,490
Total 1972	340,875	39,634	.116	51,436

r Revised.
[1] Included with "Undistributed" to avoid disclosing individual company data.
[2] Data may not add to totals shown because of independent rounding.
[3] Included with furnace plants to avoid disclosing individual company data.

Table 42.—Coke-oven crude light oil produced in the United States and derived products produced and sold in 1973, by State

(Thousand gallons)

State	Active plants [1]	Crude light oil				Derived products		
		Produced	Gallons per ton of coal	Refined on premises [2]	On hand Dec. 31	Produced	Sold [3]: Quantity	Sold [3]: Value (thousands)
Alabama	7	15,037	2.07	5,378	1,608	3,422	3,333	$759
California, Colorado, Utah	3	17,413	3.23	11,043	300	8,641	8,337	1,836
Illinois, Indiana, Michigan	10	41,398	1.82	533	1,919	(4)	(4)	(4)
Kentucky, Missouri, Tennessee, Texas, West Virginia	7	19,962	2.68	1,547	994	2,302	2,333	613
Maryland and New York	4	31,340	3.04	16,161	624	14,291	14,442	3,835
Ohio	11	32,872	2.43	19,394	941	17,159	17,004	3,597
Pennsylvania	10	68,087	2.91	75,952	2,669	68,061	57,224	15,540
Total 1973 [5]	52	226,109	2.63	130,009	9,054	113,878	102,673	26,181
At merchant plants	6	8,219	1.88	(6)	1,010	(6)	(6)	(6)
At furnace plants	46	217,891	2.67	130,009	8,044	113,878	102,673	26,181
Total 1972	52	214,201	2.66	119,485	10,151	104,484	102,502	20,727

[1] Number of plants that recovered crude light oil.
[2] Includes small quantity of material also reported in sales of crude light oil in table 33.
[3] Excludes 93,819,000 gallons of crude light oil valued at $13,183,000 sold as such.
[4] Included with Maryland and New York to avoid disclosing individual company confidential data.
[5] Data may not add to totals shown because of independent rounding.
[6] Included with furnace plants to avoid disclosing individual company confidential data.

Table 43.—Yield of light oil derivatives from refining crude light oil at oven-coke plants in the United States

(Percent)

Year	Benzene (all grades)	Toluene (all grades)	Xylene (all grades)	Solvent naphtha (crude and refined)	Other light oil products
1969	67.0	13.1	3.5	2.9	4.4
1970	63.0	12.1	3.2	3.3	5.2
1971	65.6	12.4	2.8	3.2	5.0
1972	59.3	12.8	3.1	3.0	4.7
1973	61.2	11.3	2.8	2.7	5.5

Table 44.—Benzene and toluene produced at oven-coke plants in the United States, by grade

(Thousand gallons)

Year	Benzene: Specification grades (1°, 2°, 90%)	Benzene: Other industrial grades	Toluene (all grades)
1969	97,503	4,192	19,603
1970	89,517	3,975	17,401
1971	68,756	3,391	13,345
1972	76,317	3,532	14,571
1973	85,876	3,299	14,496

Table 45.—Light oil derivatives produced at oven-coke plants in the United States and sold in 1973, by State

(Thousand gallons and thousand dollars)

State	Benzene (all grades)				Toluene (all grades)			
	Produced	Yield from crude light oil refined (percent)	Sold: Quantity	Sold: Value	Produced	Yield from crude light oil refined (percent)	Sold: Quantity	Sold: Value
Alabama	2,526	53.9	2,400	604	545	13.9	526	99
Colorado, Indiana, Utah	6,498	57.1	6,583	1,432	1,401	12.3	1,239	273
Maryland, Tennessee, Texas	14,505	77.6	14,655	3,734	606	8.0	626	131
Ohio	13,631	64.0	13,500	2,914	2,469	12.7	2,484	483
Pennsylvania	52,015	57.4	42,849	12,358	9,475	12.5	9,251	2,173
Total 1973 [1] [2]	89,175	61.2	79,987	21,042	14,496	11.3	14,127	3,160
Total 1972	79,850	59.3	80,225	16,338	14,571	12.8	13,954	2,501

State	Xylene (all grades)				Solvent naphtha (crude and refined)			
	Produced	Yield from crude light oil refined (percent)	Sold: Quantity	Sold: Value	Produced	Yield from crude light oil refined (percent)	Sold: Quantity	Sold: Value
Alabama	108	3.7	154	32	(3)	(3)	(3)	(3)
Colorado, Indiana, Utah	295	3.6	335	80	489	3.9	229	38
Maryland, Tennessee, Texas	81	1.8	92	20	595	3.8	571	106
Ohio	559	3.6	544	113	(4)	(4)	(4)	(4)
Pennsylvania	2,062	2.7	1,914	444	1,721	2.3	1,715	369
Total 1973 [1] [2]	3,104	2.8	3,040	689	2,806	2.7	2,514	513
Total 1972	3,351	3.1	3,208	578	2,815	3.0	2,596	462

[1] Data may not add to totals shown because of independent rounding.
[2] Data not broken down into merchant and furnace plants to avoid disclosing individual company confidential data.
[3] Included with Colorado, Indiana, and Utah to avoid disclosing individual company confidential data.
[4] Included with Maryland, Tennessee, and Texas to avoid disclosing individual company confidential data.

Columbium and Tantalum

By Joseph A. Sutton [1]

Demand for columbium in steelmaking increased 9% to a new record high as consumption in the ferrocolumbium form totaled 3.2 million pounds. High strength-low alloy steel continued to be in high demand and was the dominating end-use category for columbium. Higher prices for columbium and tantalum raw materials were the result of increased demand and inflationary trends that prevailed during 1973. Imports of columbium- and tantalum-mineral concentrates were about 12% and 11% below those of the previous year, respectively. Government stockpile objectives were revised downward during the year for columbium carbide powder, ferrocolumbium, columbium metal, tantalum minerals, tantalum carbide powder, and tantalum metal. Columbium and tantalum materials continued to be released from the stockpile. Superconductors made of columbium alloyed to other metals continued to be one of the most interesting and important areas for the future growth of columbium. Tantalum continued to be primarily used in capacitors and other electronic devices.

Legislation and Government Programs.—The General Services Administration (GSA) continued its columbium and tantalum disposal program and sold to industry 1,855,103 pounds of columbium and 217,203 pounds of tantalum in the forms of ores, concentrates, and minerals, 457,515 pounds of columbium in the form of ferrocolumbium, and 75,537 pounds of columbium in the form of columbium oxide powder. Total value of all sales of columbium-bearing materials was $4,591,453 in 1973, and for tantalum-bearing materials, it was $2,121,845. The quantities of columbium and tantalum materials reported in Government inventories as of December 31, 1973, are given in table 3.

Pursuant to Section 2(a) of Public Law 520 (79th Congress), Reorganization Plan No. 1 of 1958, as amended, and Executive Order 11051, GSA stockpile objectives for columbium and tantalum materials were revised in accordance with Office of Emergency Preparedness (OEP) Stockpile Objective Action 368 issued April 12, 1973. Objectives were revised downward as follows: Columbium carbide powder from 20,000 pounds of contained columbium (Cb) to 16,000 pounds; ferrocolumbium, from 930,000 pounds of contained Cb to 748,000 pounds; columbium metal, from 45,000 pounds of contained Cb to 36,000 pounds; tantalum minerals, from 2,947,045 pounds of contained tantalum (Ta) to 312,000 pounds; tantalum carbide powder, from 26,750 pounds of contained Ta to 2,900 pounds; and tantalum metal, from 360,000 pounds of contained Ta to 45,000 pounds.

The Office of Minerals Exploration (OME), U.S. Geological Survey, continued to offer financial assistance of 50% and 75% of costs for exploration of approved columbium and tantalum resources, respectively.

[1] Physical scientist, Division of Ferrous Metals—Mineral Supply.

Table 1.—Salient columbium statistics

(Thousand pounds)

	1969	1970	1971	1972	1973
United States:					
Mine production of columbite-tantalite concentrates	W	--	--	--	--
Releases from Government stocks (Cb content)[1] [2]	1,810	1,042	36	799	2,344
Consumption of raw materials (Cb content)	2,918	3,289	2,346	2,489	2,806
Production of primary products:					
Columbium metal (Cb content)	W	W	W	W	W
Ferrocolumbium (Cb content)	r 2,556	1,430	1,020	r 1,474	1,496
Consumption of primary products:					
Columbium metal (Cb content)	179	261	459	218	254
Ferrocolumbium, ferrotantalum-columbium, and other columbium and tantalum materials (Cb+Ta content)	3,328	2,591	2,880	3,676	4,056
Exports: Columbium metal, compounds, and alloys (gross weight)	41	46	21	29	96
Imports for consumption:					
Mineral concentrate (Cb content)	2,081	2,505	1,289	1,558	1,314
Columbium metal and columbium-bearing alloys (Cb content)	5	2	1	1	4
Ferrocolumbium (Cb content) e	1,430	1,300	710	1,530	2,120
Tin slags (Cb content) [3]	454	498	526	547	603
World:					
Production of columbium-tantalum concentrates (Cb content) e	14,579	18,639	8,252	13,121	20,898

e Estimate. r Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Includes columbium content in raw materials from which columbium is not recovered.
[2] Includes material released as payment-in-kind for upgrading.
[3] Receipts reported by consumers.

Table 2.—Salient tantalum statistics

(Thousand pounds)

	1969	1970	1971	1972	1973
United States:					
Mine production of columbium-tantalum concentrates	W	--	--	--	--
Releases from Government stocks (Ta content) [1]	215	161	6	87	266
Consumption of raw materials (Ta content)	928	1,733	1,116	1,280	2,221
Production of primary metal (Ta content)	1,046	916	892	1,352	1,619
Consumption of primary products:					
Tantalum metal (Ta content)	751	417	649	922	1,096
Ferrocolumbium and ferrotantalum-columbium and other columbium and tantalum materials (Cb+Ta content)	3,328	2,591	2,880	3,676	4,056
Exports:					
Tantalum ore and concentrate (gross weight)	85	122	48	r 19	16
Tantalum metal, compounds, and alloys (gross weight)	124	640	194	146	344
Tantalum and tantalum alloy powder (Ta content)	100	139	85	171	202
Imports for consumption:					
Mineral concentrate (Ta content)	412	448	502	458	428
Tantalum metal and tantalum-bearing alloys (Ta content)	11	51	40	74	101
Tin slags (Ta content) [2]	371	470	481	625	719
World:					
Production of columbium-tantalum concentrates (Ta content) e	856	701	1,093	813	770

e Estimate. r Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Includes material released as payment-in-kind for upgrading.
[2] Receipts reported by consumers.

Table 3.—Columbium and tantalum materials in Government inventories as of Dec. 31, 1973

(Thousand pounds, columbium and tantalum content)

Material	Objective	National (strategic) stockpile	Defense Production Act (DPA) inventory	Supplemental stockpile	Total
COLUMBIUM					
Concentrates	--	3,939	1,066	39	5,044
Carbide powder: Stockpile grade	16	21	--	--	21
Ferrocolumbium:					
Stockpile grade	748	623	--	--	623
Nonstockpile grade	--	347	--	--	347
Metal: Stockpile grade	36	45	--	--	45
TANTALUM					
Tantalum minerals: Stockpile grade	312	2,821	736	1	3,558
Carbide powder: Stockpile grade	3	29	--	--	29
Metal: Stockpile grade	45	201	--	--	201

DOMESTIC PRODUCTION

Domestic mining activity was insignificant during the year. One company produced a few pounds of columbium and tantalum while doing exploration and development work in Larimer County, Colo., but none of the material was marketed.

Production of columbium metal powder increased 16% in 1973, but data continued to be withheld to avoid disclosing individual company confidential information. Production of columbium metal ingot increased 23%, but again specific information was withheld. Production of tantalum metal powder (including capacitor-grade powder) increased 20% to 810 tons in 1973; production of tantalum metal ingot increased 38% to 356 tons.

Ferrocolumbium was produced by the thermite process by the Reading Alloys Co., Inc., and Shieldalloy Corp. Kawecki Berylco Industries, Inc., and Union Carbide Corp. produced the material in electric furnaces. The Foote Mineral Co., a former producer of ferrocolumbium, did not produce ferrocolumbium in 1973. In December, an official of Foote Mineral Co. announced that production and sales operations for all grades of ferrocolumbium were to be discontinued as of January 1, 1974. During the last 4 years production of ferrotantalum-columbium has not been reported by the industry.

Table 4.—Major domestic columbium and tantalum processing and producing companies in 1973

Company	Location	Columbium	Tantalum	Tantalum carbide	Ferro-columbium
Allegheny-Ludlum Industries, Inc	Brackenbridge, Pa; Watervliet, N.Y	X	--	--	--
Fansteel, Inc	N. Chicago, Ill	X	X	X	--
	Muskogee, Okla			X	--
General Electric Co	Warren, Mich	--	--		
Kawecki Division, Kawecki Berylco Industries, Inc	Boyertown, Pa	X	X	X	X
Kennametal, Inc	Latrobe, Pa	X	X	X	--
Mallinckrodt Chemical Works	St. Louis, Mo	X	X	--	--
Mining and Metals Div., Union Carbide Corp	Niagara Falls, N.Y; Marietta, Ohio; Greenville, S.C	X	X	--	X
Metals Division, Norton Co	Newton, Mass	X	X	--	--
Molybdenum Corp. of America	Washington, Pa	X	--	X	--
Newcomer Products, Inc	Latrobe, Pa	X	--	--	--
Reading Alloys Co., Inc	Robesonia, Pa	X	--	--	X
Shieldalloy Corp	Newfield, N.J	X	--	--	X
Wah Chang Albany (A Teledyne Company)	Albany, Oreg	X	X	X	--

CONSUMPTION AND USES

The quantity of columbium consumed in the form of high-purity metal was 17% above that reported in 1972 and totaled 253,882 pounds. High-purity columbium metal in powder and ingot forms continued to be used to make high-temperature ferrous and nonferrous superalloys required by the aerospace industry.

Tantalum metal (including capacitor-grade powder) consumed during the year increased from the 921,851 pounds reported in 1972 to 1,095,694 pounds. Tantalum metal continued to be used primarily in powder or ingot form in the manufacture of capacitors, other electronic equipment, and corrosion-resistant chemical equipment.

Columbium and tantalum used in ferroalloys for adding to steels to control grain size accounted for 80% of the ferrocolumbium (FeCb), ferrotantalum-columbium (FeTa-Cb), and other columbium and tantalum materials consumed. Consumption of FeCb, FeTa-Cb, and other columbium and tantalum materials increased in all end-use categories except electric steel, tool steel and miscellaneous and unspecified. The largest increase in the consumption of columbium plus tantalum occurred in the carbon steel category, but the largest quantity required was in the high strength-low alloy steels category.

Domestic consumption of columbium and tantalum in ferroalloy forms of FeCb, FeTa-Cb, and of other columbium and tantalum materials, by major end-use categories, was as follows: High strength-low alloy steel (29%); carbon steel (25%); stainless and heat resisting steel (18%); superalloys (17%); full alloy steel (9%); alloys other than alloy steels and superalloys (1%); and miscellaneous and unspecified (1%).

The total quantity of columbium consumed in steelmaking (excluding electric and tool steels) in the FeCb form was approximately 3.1 million pounds, an increase of 13% over the total for 1972. Consumption of columbium and tantalum in the ferroalloy form of FeTa-Cb continued to be small and amounted to less than 1% of the columbium and tantalum consumed in the forms of FeCb, FeTa-Cb, and other columbium and tantalum materials. The major end-use category for columbium and tantalum consumed in the form of FeTa-Cb was superalloys.

Kawecki Berylco Industries, Inc., reported that the use of tantalum powder and wire was on the increase in electronic capacitors.[2] For example, a new Interstate Highway Emergency Call Box System was reported to rely on 30 tantalum capacitors in the main electronic system of each call box. Superconducting materials of columbium-titanium coated with tin and columbium-titanium filaments embedded in a high-purity copper matrix were, also, reported as being considered for use in levitated trains and for electrical generator and motor applications.

The 10,000-square-foot facility in North Chicago, used by Fansteel, Inc., for production of mill forms such as wire, sheet and foil, rod, tubing, as well as powder, was modernized to conform to present needs.[3] Major metal rolling and handling equipment from Fansteel's Baltimore plant, closed in July 1972, was relocated in the plant. The refurbished plant has the capability for producing refractory materials in sheet gages to precision tolerances in thicknesses down to 0.003 inch.

Teledyne Wah Chang was reported to be another source of supply to the electronics industry for capacitor-grade tantalum wire.[4]

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[2] Kawecki Berylco Industries, Inc. 1973 Annual Report. 13 pp.

[3] American Metal Market. Fansteel Metals Completes Plant Modernization. V. 80, No. 73, Apr. 13, 1973, p. 7.

[4] American Metal Market. Wah Chang Develops Capacitor Tantalum. V. 80, No. 96, May 11, 1973, p. 11.

Table 5.—Reported shipments of columbium and tantalum materials

(Pounds of metal content)

Material	1972	1973	Percent change
Columbium products:			
Compounds, including alloys	925,200	1,216,800	+31.5
Metal, including worked products	101,900	143,000	+40.3
All other	62,800	300	−99.5
Total Cb	1,089,900	1,360,100	+24.8
Tantalum products:			
Oxides and salts	54,900	142,300	+159.2
Alloy additive	43,000	17,300	−59.8
Carbide	146,900	173,400	+18.0
Powder and anodes	540,700	790,500	+46.2
Ingot (unworked consolidated metal)	[1] −1,900	16,000	--
Mill products	246,400	321,200	+30.4
Scrap	58,100	40,500	−30.3
Other	300	1,300	+333.3
Total Ta	1,088,400	1,502,500	+38.0

[1] As reported by source.

Source: Tantalum Producers Association.

Table 6.—Consumption of ferrocolumbium, ferrotantalum-columbium, and other columbium and tantalum materials in the United States in 1973, by end use

End use	Pounds of contained columbium plus tantalum
Steel:	
Carbon	998,204
Stainless and heat resisting	712,525
Full alloy	361,143
High strength-low alloy	1,181,950
Electric	W
Tool	W
Superalloys	685,743
Alloys (exclude alloy steels and superalloys)	67,853
Miscellaneous and unspecified	48,969
Total	4,056,387

W Withheld to avoid disclosing individual company confidential data; included in "Miscellaneous and unspecified."

STOCKS

The following columbium and tantalum materials (in pounds) were reported in yearend inventories:

Mineral	Dec. 31, 1972	Dec. 31, 1973
COLUMBIUM		
Primary metal	55,984	108,697
Ingot	62,826	51,290
Scrap	75,483	80,025
Oxide	553,800	495,451
Other compounds	r 15,052	13,946
TANTALUM		
Primary metal	267,975	224,261
Capacitor-grade powder	154,871	135,098
Ingot	56,074	65,088
Scrap	232,039	258,568
Oxide	90,386	37,101
Potassium tantalum fluoride (K_2TaF_7)	163,606	130,763
Other compounds	r 35,255	31,051

r Revised.

Stocks of columbium and tantalum raw materials, as reported by consumers and dealers at yearend 1973 (in short tons-1972 figures in parentheses) were as follows: Columbite, 1,310 (1,104); tantalite, 745 (1,120); pyrochlore, 229 (501); tin slag, 34,691 (33,775); and other, none (61).

Consumers inventories of ferrocolumbium and ferrotantalum-columbium as of December 31, 1973, were as follows (with 1972 yearend stocks in parentheses): Ferrocolumbium 1,456,283 pounds contained columbium (814,607); ferrotantalum—columbium, 22,867 pounds contained columbium plus tantalum (18,592); and other columbium and tantalum materials, 47,182 pounds contained columbium plus tantalum (40,061). Producer stocks of ferrocolumbium at yearend 1973 were 680,320 pounds contained columbium (638,000).

PRICES

Prices for pyrochlore and columbite were higher at the end of 1973 than at the end of 1972. Contract rates for Canadian pyrochlore, f.o.b. mine and mill, went from $1.39 per pound of CB_2O_5 content to $1.44. Those for Brazilian pyrochlore similarly went from $1.37 to $1.42. Columbite ore, c.i.f U.S. ports, increased from $1.10 to $1.15 per pound of contained pentoxides for material having a Cb_2O_5—to Ta_2O_5 ratio of 10 to 1 at the beginning of the year to $1.35 to $1.45 per pound at yearend.

Tanco tantalite, Bernic Lake concentrate produced by Tantalum Mining Corp. of Canada, at the beginning of the year was quoted at $7.00 per pound of Ta_2O_5, and at yearend, $10.00. Spot prices for other tantalite ores or concentrates at the beginning of the year were quoted at $5.25 to $6.00 per pound of Ta_2O_5, 60% basis, c.i.f. U.S. ports, and at yearend, $7.50 to $8.50.

Thailand tin slag, Union Carbide-Billiton tin smelter 12% Ta_2O_5 content, at the beginning of the year was quoted at $4.00 per pound of Ta_2O_5 content, and at yearend $4.50.

Price quotations for various grades of ferrocolumbium per pound of columbium content, ton lots, f.o.b. shipping point, at the beginning of the year were as follows: Low alloy, standard grades, $2.80 per pound of columbium content; high-purity grades, $4.12 to $6.81. Quotations at yearend increased to $3.10 for low-alloy grades and narrowed to $5.00 to $5.26 for high-purity grades.

The price of columbium metal remained unchanged during the year. Columbium powder was quoted at $11 to $22 per pound for metallurgical-grade material, and $12 and $23 per pound for reactor-grade material. Columbium ingot was quoted at $16 to $27 per pound for metallurgical-grade material and $17.50 to $28.00 per pound for reactor-grade material.

Prices for tantalum metal in the forms of powder and rod were lower at the end of 1973 than at the end of 1972. Tantalum metal at yearend was quoted at $30 to $37 per pound for powder, $30 to $40 per pound for rod, and $36 to $60 per pound for sheet.

Table 7.—Average grade of concentrate received by U.S. consumers and dealers in 1973, by country of origin

(Percent contained pentoxides)

	Columbite		Tantalite	
	Cb_2O_5	Ta_2O_5	Ta_2O_5	Cb_2O_5
Australia	--	--	45	31
Belgium	--	--	35	44
Brazil [1]	58	--	37	28
Canada	--	--	50	4
Congo (Brazzaville)	--	--	30	32
French Guiana	--	--	56	25
Malaysia	52	11	16	38
Nigeria	63	10	34	4
Portugal	--	--	33	36
Rwanda	--	--	29	43
South Africa, Republic of	--	--	32	30
Spain	--	--	25	31
Zaire	--	--	31	39

[1] Material reported from Brazil as columbite represents primarily pyrochlore.

FOREIGN TRADE

West Germany, Japan, and the United Kingdom received the majority of the columbium and tantalum exported during the year. Unwrought tantalum alloys in crude form and scrap, the largest export item by volume, were shipped to West Germany (36%), Belgium-Luxembourg (21%), Japan (14%), and Italy (6%). The remainder of this material (1% of the total) was exported to France, Austria, Mexico, Brazil, and Sweden. Tantalum and tantalum alloy powder, the largest export item by value, was shipped to Japan (27%), West Germany (21%), the United Kingdom (20%), France (9%), Italy (9%), and Canada (8%). The remainder of the tantalum and tantalum alloy powder (6% of the total) was destined for Switzerland, the Netherlands, Yugoslavia, India, and Sweden. Wrought tantalum and tantalum alloys, the second largest export item by value, were exported to Japan (27%), the

United Kingdom (23%), West Germany (13%), Canada (12%), France (12%), the Netherlands (6%), Switzerland (3%), and Italy (2%). The remainder of the tantalum material (2% of the total) was exported to Mexico, Nicaragua, Brazil, Argentina, Sweden, Belgium-Luxembourg, Austria, Yugoslavia, Israel, India, Australia, and the Republic of South Africa. Tantalum ores and concentrates, believed not to be of domestic origin, were shipped to Japan. Wrought columbium and columbium alloys were mostly exported to the Netherlands (39%), Japan (32%), the United Kingdom (12%), West Germany (8%), France (4%), and Canada (3%). The rest of this material was exported to Mexico, Austria, Switzerland, Italy, India, and the Republic of South Africa. Unwrought columbium alloys in crude form and scrap were shipped mostly to West Germany (61%), the United Kingdom (27%), and Japan (9%); the remainder (3% of the total) went to the Netherlands, Switzerland, and Trinidad and Tobago.

Imports for consumption of unwrought columbium metal, waste, and scrap, all from West Germany, increased from 400 pounds valued at $3,714 in 1972 to 3,974 pounds valued at $11,794 in 1973. Imports for consumption of wrought columbium metal decreased from 265 pounds valued at $14,876 in 1972 to 25 pounds valued at $1,988 in 1973. This import item was supplied by the U.S.S.R. (96%) and the United Kingdom (4%). Unwrought columbium alloys were not imported in 1973.

Imports for consumption of unwrought tantalum metal, including waste and scrap, were 100,808 pounds valued at $727,665 in 1973. The material was imported from West Germany (55%), Mexico (23%), France (9%), the United Kingdom (8%), Canada (3%), and the Netherlands and Belgium-Luxembourg (2%). Imports of wrought tantalum from Austria (56%), Switzerland (33%), and the United Kingdom (11%) decreased from 90 pounds valued at $3,664 in 1972 to 18 pounds valued at $2,098 in 1973. Imports of unwrought tantalum alloys, all from Japan, totaled 93 pounds valued at $3,800 and represented a sharp decrease from the 2,000 pounds valued at $13,183 that were imported in 1972.

In 1973, imports for consumption of columbium-mineral concentrates and tantalum-mineral concentrates were 12% and 11%, respectively, below those of 1972.

Receipts in tin slags came primarily from Thailand.

Table 8.—U.S. exports of columbium and tantalum, by class

(Thousand pounds, gross weight, and thousand dollars)

Class	1972 Quantity	1972 Value	1973 Quantity	1973 Value
Columbium and columbium alloys, unwrought and waste and scrap	2	40	20	140
Columbium and columbium alloys, wrought	27	413	76	650
Tantalum ores and concentrates	19	29	16	13
Tantalum and tantalum alloys, wrought	24	r 1,267	44	2,368
Tantalum metals and alloys, in crude form and scrap	122	1,014	300	1,581
Tantalum and tantalum alloy powder	171	3,572	202	5,312

r Revised.

Table 9.—Receipts of tin slags reported by consumers

(Thousand pounds)

Year	Gross weight	Cb_2O_5 content	Ta_2O_5 content
1969	8,327	649	453
1970	10,275	713	573
1971	9,064	753	596
1972	9,782	783	762
1973	8,607	863	878

Table 10.—U.S. imports for consumption of columbium-mineral concentrates, by country

(Thousand pounds and thousand dollars)

Country	1972				1973			
	Gross weight	Cb [e] content	Ta [e] content	Value	Gross weight	Cb [e] content	Ta [e] content	Value
Angola	--	--	--	--	--	--	--	--
Belgium-Luxembourg [1]	5	1	1	9	--	--	--	--
Brazil	2,347	951	--	1,363	2,361	957	--	1,686
Canada	65	26	--	52	1	(2)	--	1
Congo (Brazzaville)	--	--	--	--	17	4	5	54
Germany, West	2	(2)	1	2	39	8	10	13
Malaysia	75	35	6	44	232	84	21	154
Mozambique	--	--	--	--	--	--	--	--
Nigeria	648	281	21	362	67	30	5	60
Portugal	14	4	4	24	31	8	8	49
Rwanda	--	--	--	--	8	3	1	19
Singapore	--	--	--	--	--	--	--	--
Spain	6	2	1	9	8	2	2	16
Uganda	15	6	3	11	--	--	--	--
United Kingdom	50	14	16	51	--	--	--	--
Zaire	--	--	--	--	62	15	17	149
Total	3,227	1,320	53	1,927	2,826	1,111	69	2,201

[e] Estimated by Bureau of Mines.
[1] Presumably country of transshipment rather than original source.
[2] Less than ½ unit.

Table 11.—U.S. imports for consumption of tantalum-mineral concentrates, by country

(Thousand pounds and thousand dollars)

Country	1972				1973			
	Gross weight	Cb [e] content	Ta [e] content	Value	Gross weight	Cb [e] content	Ta [e] content	Value
Argentina	--	--	--	--	--	--	--	--
Australia	404	88	146	852	325	70	120	986
Belgium-Luxembourg [1]	16	4	4	27	--	--	--	--
Brazil	362	73	119	787	206	40	62	482
Canada	119	3	50	416	236	7	97	832
Congo (Brazzaville)	33	--	6	78	--	--	--	--
French Guiana	--	--	--	--	3	(2)	1	5
Germany, West	48	9	12	109	--	--	--	--
Malaysia	--	--	--	--	--	--	--	--
Mozambique	30	6	10	65	--	--	--	--
Nigeria	3	1	1	2	--	--	--	--
Portgual	--	--	--	--	--	--	--	--
Rwanda	66	19	16	81	39	11	9	49
South Africa, Republic of	--	--	--	--	12	3	3	20
Spain	5	1	1	9	58	13	12	117
Thailand	26	6	6	33	--	--	--	--
Uganda	2	1	(1)	1	--	--	--	--
United Kingdom	27	7	9	37	--	--	--	--
Zaire	88	20	25	166	218	59	55	367
Total	1,229	238	405	2,663	1,097	203	359	2,858

[e] Estimated by Bureau of Mines.
[1] Presumably country of transshipment rather than original source.
[2] Less than ½ unit.

Table 12.—U.S. import duties

Classification number	Article	Rate of duty per pound [1] Effective Jan. 1, 1973—1974
601.21	Columbium concentrate	Free.
601.42	Tantalum concentrate	Do.
607.80	Ferrocolumbium and ferrotantalum-columbium	5% ad valorem.
	Columbium:	
628.15	Unwrought, waste and scrap	Do.
628.20	Wrought	9% ad valorem.
628.17	Unwrought Cb alloys	7.5% ad valorem.
	Tantalum:	
629.05	Unwrought, waste and scrap	5% ad valorem.
629.10	Wrought	9% ad valorem.
629.07	Unwrought Ta alloys	7.5% ad valorem.
423.00	Columbium and tantalum chemicals	5% ad valorem.

[1] Not applicable to certain specified Communist countries.

WORLD REVIEW

Australia.—On January 31, the government of Australia imposed export controls on all Australian minerals to be exported in raw or semiprocessed form. The objective for such an action was to insure that Australia's export prices are at reasonable levels in relation to export prices in other countries and to encourage more domestic processing of Australia's mineral resources before being exported.

Brazil.—During 1973 Brazil maintained its standing as the major world producer of columbium minerals. Companhia Brasileira de Metalúrgia e Mineração (CBMM), the country's leading producer, continued to recover columbium concentrate from rich pyrochlore ores at its Axará mine and mill operations and to produce ferrocolumbium (FeCb) at its pyrometallurgical plant by the thermite process.

Columbium and tantalum associated with columbite-tantalite and microlite continued to be produced in limited quantities from relatively small pegmatite operations located principally in Minas Gerais.

Canada.—St. Lawrence Columbium and Metals Corp. produced concentrates from its underground mining operations and milling facilities near Oka, Quebec, and continued to be Canada's sole columbium producer. In spite of labor problems that resulted in work slowdowns and a 1-month strike, the firm milled 612,487 tons of ore, which represented a 4% increase over that milled in fiscal year 1972 (ended September 30, 1972).

Two new pyrochlore ore zones were reported to be within easy reach of the present mine workings at the St. Lawrence Columbium and Metals Corp.[5] A development drift and two crosscuts were advanced on the 500-foot level of the Main Oka ore body that passes through the two new zones. Ore mined from these areas was used in a 1,750-ton mill test conducted by the company. Results of the test showed the new ore to be amenable to the company's concentration process and to be superior to ore presently being mined from the Main Oka ore body in regards to calcite content.

Ore reserves available to St. Lawrence Columbium and Metals Corp. at the end of the fiscal year (September 30, 1973) were reported to be 10,700,000 tons of proven ore, 6,500,000 tons of probable ore, and 8,200,000 tons of possible ore, giving a total of 25,400,000 tons of ore reserves at 0.443% Cb_2O_5.[6]

Chemalloy Minerals Ltd., which holds 75% of Tantalum Mining Corp. of Canada, confirmed that it offered to buy back from the Manitoba Development Corp. the 25% interest that it sold to the government agency in 1971.[7] Government action on the offer was still pending at yearend.

Copperfields Mining Corp. Ltd. and Quebec Mining Exploration Co. (SOQUEM) completed its exploration, definition drilling, and underground bulk sampling, and 11-month pilot plant program on its St. Honore carbonatite deposit, near Chicoutimi, Quebec.[8] Negotiations were initiated to finance into production the St. Honore columbium venture. Senior financing terms were arranged in principle and include $6,650,000 from a consortium of Canadian chartered banks and $3,000,000 from a customer with the balance to be provided by the sponsors. Long-term sales contracts for the pyrochlore concentrate to be produced at the mill were negotiated with companies in Europe, Japan, and the United States, and these markets were supposed to require about 95% of the anticipated mill production. The ore reserve of 40 million tons of 0.76% columbium pentoxide, based on a 0.5% cutoff, was to be mined underground.[9] Present plans call for a 1,500-ton-per-day mining and milling operation by mid-1975.

Japan.—According to the Ministry of International Trade and Industry (MITI), Japanese production of tantalum metal was 143% above that of 1972 for the period January through September and was equal to 63,933 pounds.

Mozambique.—In 1972 Mozambique's production of tantalite and microlite was reported to be 92,593 and 134,480 pounds,

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[5] Northern Miner (Toronto). St. Lawrence Columbium Gets Lift From Fine New Ore Area. V. 59, No. 14, June 21, 1973, p. 1.
St. Lawrence Columbium and Metals Corp. 1973 Annual Report. 19 pp.

[6] St. Lawrence Columbium and Metals Corp. 1973 Annual Report. 19 pp.

[7] American Metal Market. Chemalloy Seeks Mine Repurchase. V. 80, No. 102, May 24, 1973, p. 3.

[8] Copperfields Mining Corp. Ltd. 1973 Annual Report. 8 pp.

[9] Metals Sourcebook. Other Metals. No. 10, May 21, 1973, p. 4.

respectively. The main pegmatite deposits, which have been the source of Mozambique's tantalum ores (columbo-tantalite), occur in the Alto Ligonha region.

Nigeria.—Two Japanese companies, Sumitomo Metal Mining Co. and Mitsubishi Corp., acquired a 76% interest in Tin and Associated Minerals, Ltd., the company that manages the 600-ton-per-year columbite mine at Odegi, Nigeria. The acquired interest was obtained from Quebec Iron and Titanium Corp., a Canadian subsidiary of the U.S. Kennecott Copper Corp., of Sorel, Quebec, and Anthony Coshinos, an American. The Odegi columbium mine at Jos in the northern part of Nigeria accounts for about one-third of the country's total output of columbite concentrate.

Zaire.—As a byproduct of tin mining, Zaire-Etain produced 143,299 pounds of columbium-tantalum concentrate in 1972. The mining operations from which the columbium-tantalum concentrate were produced are located in north central Shaba where cassiterite is mined from an ore bed approximately 3 miles long and from 328 to 1,312 feet wide.

Philips Brothers Sobaki (PHIBRAKI), continued to produce mixed cassiterite/columbium-tantalum ore from deposits at

Table 13.—Columbium and tantalum: World production of mineral concentrates by country [1]

(Thousand pounds)

Country [2]	Gross weight [3]			Columbium content [4]			Tantalum content [4]		
	1971	1972	1973 [p]	1971	1972	1973 [p]	1971	1972	1973 [p]
Argentina:									
Columbite	4			[5] 1			[5] 1		
Tantalite	6	--	--	1	--	--	3	--	--
Australia: Columbite-tantalite	165	558	441	[5] 42	121	96	[5] 87	200	163
Brazil:									
Columbite	139	143 }	[6] 287	35	36 }	[6] 56	35	36 }	[6] 87
Tantalite	[r] 640	660 }		121	134 }		210	216 }	
Pyrochlore	13,435	21,242	42,827	5,307	8,603	17,345	--	--	--
Canada:									
Tantalite	[e] 843	[e] 77	[e] 215	34	3	9	[7] 368	[7] 34	[7] 94
Pyrochlore	[r] [e] 4,669	[e] 7,756	[e] 5,739	[7] 1,631	[7] 2,708	[7] 2,004	--	--	--
Malaysia: Columbite-tantalite	54	196	202	25	90	74	8	12	18
Mozambique:									
Tantalite	[r] 128	93	64	19	19	13	40	30	21
Microlite (tantalum concentrate)	117	134	123	5	5	5	64	74	68
Nigeria:									
Columbite	[r] 3,031	3,000	2,734	891	1,299	1,203	124	84	224
Tantalite	9	2	2	3	1	(8)	2	1	1
Portugal: Tantalite	24	26	26	6	7	7	[5] 6	[5] 6	[5] 6
Rhodesia: Columbite-tantalite [e]	90	90	90	11	11	11	34	34	34
Rwanda: Columbite	71	[e] 82	[e] 90	20	[e] 23	[e] 27	15	[e] 19	[e] 21
South Africa, Republic of: Tantalite	[r] 1	(8)	--	(8)	(8)	--	(8)	(8)	--
Thailand:									
Columbite	[r] 46	15	44	22	7	16	7	1	4
Tantalite	[r] 46	15	9	10	3	2	11	4	2
Uganda: Columbite-tantalite	17	6	[e] 6	7	2	[e] 2	3	1	[e] 1
Zaire: Columbite-tantalite	[r] 262	214	102	61	49	28	75	61	26
Total	[r] 23,797	34,309	53,001	8,252	13,121	20,898	1,093	813	770

[e] Estimate. [p] Preliminary. [r] Revised.

[1] Excludes columbium and tantalum-bearing tin concentrates and slags.

[2] In addition to the countries listed, Burundi, Spain, South-West Africa and the U.S.S.R. also produce or are believed to produce columbium and tantalum mineral concentrates, but available information is inadequate to make reliable estimates of output levels.

[3] Data on gross weight generally has been presented as reported in sources, divided into concentrates of columbite, tantalite, pyrochlore and microlite where information is available to do so, and reported in groups such as columbite-tantalite where it is not.

[4] Unless otherwise specified, content is estimated on the basis of the content reported for U.S. imports from the country in question. Entries specifically marked as estimates are based on estimated gross weights.

[5] Content calculated on basis of data in source publication recording gross weight.

[6] Exports.

[7] Metal content calculated from data reported in source publication (in terms of contained pentoxide).

[8] Less than ½ unit.

Kabili and in 1972 produced 194,181 pounds of the ore, which was 11,729 pounds less than that produced in 1971.

Cobelmin-Zaire (COBELMIN), a subsidiary of Compagnie Belge d'Enterprises Minières, continued to operate concessions owned by Compagnie Minière Des Grands Lacs (MGL) and Minerga. In 1972, production of columbium-tantalum-bearing materials was down 41%.

TECHNOLOGY

One phase of Bureau of Mines research was directed toward improving the methods of preparing metals and alloys from ores and compounds. A kinetics study of the reduction of Cb_2O_5 with NH_3 was conducted at 600° to 1,300°C, using vertical fixed-bed, flow-through reactors, with the goal of using the nitride as an intermediate in the preparation of columbium metal by way of a thermal decomposition step.[10] The effects of such reactor materials as stainless steel, nickel, molybdenum, graphite, alumina, and Vycor upon ammonia reactivity toward Cb_2O_5 were investigated. Columbium pentoxide was shown to form three types of reactor products, o-oxynitride at temperatures below 800°C, CbO_2 between 800° and 850°C, and hexagonal CbN at higher temperatures. The most rapid and complete reaction occurred with molybdenum or alumina reactors at 1,200°C.

A new high-strength corrosion-resistant alloy was added to the Latrobe Steel Co.'s specialty alloys production line.[11] The new alloy, known as MultiPhase MP 159 (U.S. Patent 3,767,385), was reported to be particularly suitable for such applications as jet engine components and high-stress parts and components in marine and petrochemical machinery and equipment. Its nominal composition includes 35.7% cobalt, 25.5% nickel, 19.0% chromium, 9.0% iron, 7.0% molybdenum, 3.0% titanium, 0.6% columbium, and 0.2% aluminum. Tests have shown the alloy to be extremely resistant to crevice corrosion and stress-corrosion cracking in hostile environments.

Columbium pentoxide and tungstic oxide have been used for a number of years as additives to titania enamels for the purpose of adjusting the color of these materials to a bluer shade of white. Prior to a study conducted by R. A. Eppler of Pemco Products, Glidden-Durkee Division of SCM Corp., Baltimore, Md., the exact role these additives played in adjusting the shade of titanic enamel was not known.[12] X-ray diffraction data reported, indicates that columbium pentoxide and tungsten oxide have pronounced effects on the solubility of titania in a titania opacified porcelain enamel. Columbium pentoxide depresses the solubility of titania at firing temperatures, and tungsten oxide lowers the temperature at which the minimum titania solubility occurs so that high concentrates of small anatase crystals can be obtained.

A new ion exchanger, tantalum antimonate, was synthesized and reported to be reproducible and chemically stable.[13] The ion exchanger was synthesized by mixing O.1M tantalum and antimony pentachloride solution in the ratio of 1:2 at room temperature and by adjusting the pH of the solution to 1 with ammonia and by refluxing the precipitate obtained with the mother liquor for 16 hours. Quantitative separations of such mixtures as VO^{2+}-Al^{3+}-Ti^{4+}, VO^{2+}-Fe^{3+}-Ti^{4+}, and UO_2^{2+}-Ti^{4+} were reported to be made with the tantalum antimonate ion exchanger.

The superconductivity field continued to be one of the most interesting and important areas for the future growth of columbium. Superconductors made of columbium alloyed to other metals are being considered for use in such commercial applications as electromagnets, electrical machinery, power transmission lines, and high-speed magnetic suspended trains.[14]

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10 Guidotti, R. A., and D. G. Kesterke. The Use of Nitride Intermediates in the Preparation of Metals. A Study of the Reduction of Nb_2O_5 with NH_3. Met. Trans., v. 4, No. 5, May 1973, pp. 1233-1237.

11 American Metal Market. Latrobe Claims New Strong, Corrosion-Resistant Alloy. V. 80, No. 244, Dec. 18, 1973, p. 16.

12 Eppler, R. A. Niobium and Tungsten Oxides in Titania-Opacified Porcelain Enamels. Am. Cer. Soc. Bull., v. 52, No. 12, December 1973, pp. 879-881.

13 Qurechi, M., J. P. Gupta, and V. Sharma. Synthesis of a Reproducible and Chemically Stable Tantalum Antimonate. Anal. Chem., v. 45, No. 11, September 1973, pp. 1901-1906.

14 Popular Science. Cryogenic Power Lines: Cool Aid for Our Energy Crisis. October 1972, pp. 69-71 and 130.

An important step toward wider application in this field was made by a Westinghouse research worker. By means of a new sputtering process, John R. Gavaler produced a columbium-germanium compound Cb_3Ge, which becomes superconducting at 22.3K, thus allowing the use of a cooling system employing liquid hydrogen instead of lower boiling liquid helium.[15]

The first new piezoelectric material to be developed in many years was lithium tantalate. Single crystals of ferroelectric lithium tantalate for use in piezoelectric resonator and filter devices are being grown at Western Electric's Merrimack Valley Works by the Czochralski crystal-pulling technique.[16]

The continuing interest in methods of extraction and beneficiation of columbium and tantalum values was reflected by some of the patents issued during the year.[17]

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[15] Science. Superconductivity: Surpassing the Hydrogen Barrier. V. 183, Jan. 25, 1974, pp. 293–296.

Chemical and Engineering News. Science: A Superconductor with a High Critical Temperature. V. 51, No. 38, Sept. 17, 1973, p. 15.

[16] Rudd, D. W., and A. A. Ballman. Growth of Lithium Tantalate Crystals for Transmission Resonator and Filter Devices. The Western Electric Engineer, v. 17, No. 2, April 1973, pp. 14-18.

[17] Gomes, J. M., K. Uchida, and M. M. Wong. Recovery of Niobium and Tantalum. U.S. Pat. 3,725,221, Apr. 3, 1973.

Gustison, R. A. (assigned to Kawecki Berylco Industries, Inc.). Electric Furnace Method of Beneficiating Tantalum- And Niobium-Containing Tin Slags and the Like. U.S. Pat. 3,721,727, Mar. 20, 1973.

Gammill, A. M., T. C. Runion, and W. R. Householder (assigned to Nuclear Fuel Services Inc.). Ore Separation Process. U.S. Pat. 3,740,199, June 19, 1973.

Capps, R. H., and G. S. Harman (assigned to Union Carbide Corp.). Method for Recovering Tantalum and/or Columbium. U.S. Pat. 3,712,939, Jan. 23, 1973.

Copper

By Harold J. Schroeder [1]

World mine production of copper increased 7% to 7.86 million tons, a record high for the sixth consecutive year. All major producing countries except Peru and Zambia contributed to the increase. Production from new mines or expansions to operating properties that were completed during 1972 and 1973 more than offset losses to production from strikes, political events, and transport difficulties.

In the United States consumption of refined copper increased substantially to a new record-high quantity. There was a modest increase in mine production and smelter production from primary materials with the latter category a new record high. Refinery output from primary materials declined but the output from scrap increased significantly with the total showing a slight decrease. Foreign trade in unmanufactured copper was characterized by a small reduction in net imports as exports rose significantly and imports were only slightly higher. Industrial stocks of refined copper were drawn down during the year to compensate for a level of consumption in excess of supplies from production and net imports. Changing market conditions were reflected in price increases of approximately 9½ cents per pound in three steps during the first quarter of the year and 8 cents in December for yearend quotations for electrolytic wirebar copper in a range of 68.15 to 69.25 cents per pound.

Legislation and Government Programs.—Copper in the national stockpile on January 1, 1973, was 60,112 tons of oxygen-free, high-conductivity (OFHC) copper, 7,067 tons of copper in beryllium-copper master alloys, and 191,480 tons of copper in "other" classifications, for a total of 258,659 tons, 33% of the objective of 775,000 tons. In March the copper stockpile objective was reduced to zero and on December 28, the President signed into law Public Law 93–214, authorizing the sale of 251,600 tons of stockpile copper. The General Services Administration decided to transfer 85,000 tons of the excess metal to the U.S. Bureau of the Mint and to sell the balance for domestic consumption on a sealed bid basis.

The Office of Minerals Exploration continued to offer up to 50% government participation in the authorized cost of exploration for copper deposits. There were no contracts executed in 1973 that involved copper.

Defense set-asides for copper controlled materials were unchanged during 1973. The controlled items and their percent set-asides were: Unalloyed brass mill products—sheet (2); rod (9), and tube (2); alloyed brass mill products—sheet (4) and rod (10); copper wire mill products (2); and copper foundry products (3).

The suspension of duties on unwrought copper and copper-base scrap, which had expired on June 30, 1972, after being in effect since February 9, 1966, was reinstated by Public Law 93–77, effective from July 1, 1973, to June 30, 1974. In addition to reinstating the duty suspension, the law also revised the peril point for automatically revoking the suspension from 36 to 51 cents per pound.

[1] Physical scientist, Division of Nonferrous Metals—Mineral Supply.

Table 1.—Salient copper statistics

	1969	1970	1971	1972	1973
United States:					
Ore produced --thousand short tons--	223,752	257,729	242,656	266,831	289,998
Average yield of copper percent--	0.60	0.59	0.55	0.55	0.53
Primary (new) copper produced—					
From domestic ores, as reported by—					
Mines ----------short tons--	1,544,579	1,719,657	1,522,183	1,664,840	1,717,940
Value ------thousands--	$1,468,400	$1,984,484	$1,583,071	$1,704,796	$2,044,349
Smelters --------short tons--	1,547,496	1,605,265	1,470,815	1,649,130	1,705,065
Percent of world total --	24	24	22	23	22
Refineries -------short tons--	1,468,889	1,521,183	1,410,523	1,680,412	1,698,337
From foreign ores, matte, etc., as reported by refineries-do----	273,926	243,911	181,259	192,821	170,151
Total new refined, domestic and foreign --------do----	1,742,815	1,765,094	1,591,782	1,873,233	1,868,488
Secondary copper recovered from old scrap only ------------do----	574,890	504,071	445,194	458,194	441,841
Exports:					
Metallic copper -----------do----	241,254	273,577	262,838	241,600	292,504
Refined -----------------do----	200,269	221,211	187,654	182,743	189,396
Imports, general:					
Unmanufactured ---------do----	413,860	392,480	359,479	415,611	417,434
Refined -----------------do----	131,171	132,143	163,988	192,379	201,513
Stocks Dec. 31: Producers:					
Refined -----------------do----	39,000	130,000	75,000	57,000	37,000
Blister and materials in solution ---------------do----	291,000	340,000	303,000	281,000	265,000
Total ---------------do----	330,000	470,000	378,000	338,000	302,000
Withdrawals (apparent) from total supply on domestic account:					
Primary copper ----------do----	1,683,000	1,585,000	1,623,000	1,901,000	1,901,000
Primary and old copper (old scrap only) -----------do----	2,258,000	2,089,000	2,068,000	2,359,000	2,342,000
Price: Weighted average, cents per pound -----------------------	47.9	58.2	52.0	51.2	59.5
World:					
Production:					
Mine --------------short tons--	6,223,820	6,638,042	r 6,688,634	r 7,329,378	7,856,682
Smelter -----------------do----	6,413,940	6,751,531	r 6,591,741	r 7,339,607	7,837,966
Price: London, average cents per pound ---------------------------	66.24	62.96	48.49	48.53	80.86

r Revised.

DOMESTIC PRODUCTION

PRIMARY COPPER

Mine Production.—Domestic mine production of recoverable copper was 1.72 million tons, an increase of 3% and only slightly below the record high of 1970. Principal copper-producing States were Arizona, with 54% of the total, Utah (15%), New Mexico (12%), Montana (8%), Nevada (5%), and Michigan (4%). These six States accounted for 98% of the total production.

Open pit mines accounted for 83% of mine output and underground mines for 17%. The production of copper from dump and in-place leaching, mainly recovered by precipitation with iron, was 159,022 tons or 9% of mine output. Total copper recovered by leaching methods was 241,917 tons, of which 211,859 tons was precipitated with iron and 35,058 tons was electrowon.

Duval Corp., a subsidiary of Pennzoil Co., operated the Duval Sierrita mine near Tucson, Ariz., at a steadily increasing rate during the year and in December a new high average daily operating rate of 89,000 tons of ore was achieved. Duval's Esperanza property adjacent to Sierrita resumed operations early in 1973 following a 1-year shutdown owing to a shortage of smelting capacity to treat stockpiled concentrate. Plant modifications initiated during the shutdown made possible a 25% increase in throughput.

The Anaconda Company produced 127,800 tons of copper from underground and open pit operations at Butte, Mont., compared with 125,800 tons in 1972. Production included 1,650 tons from the Continental East pit which reached operational status late in the year and is designed to

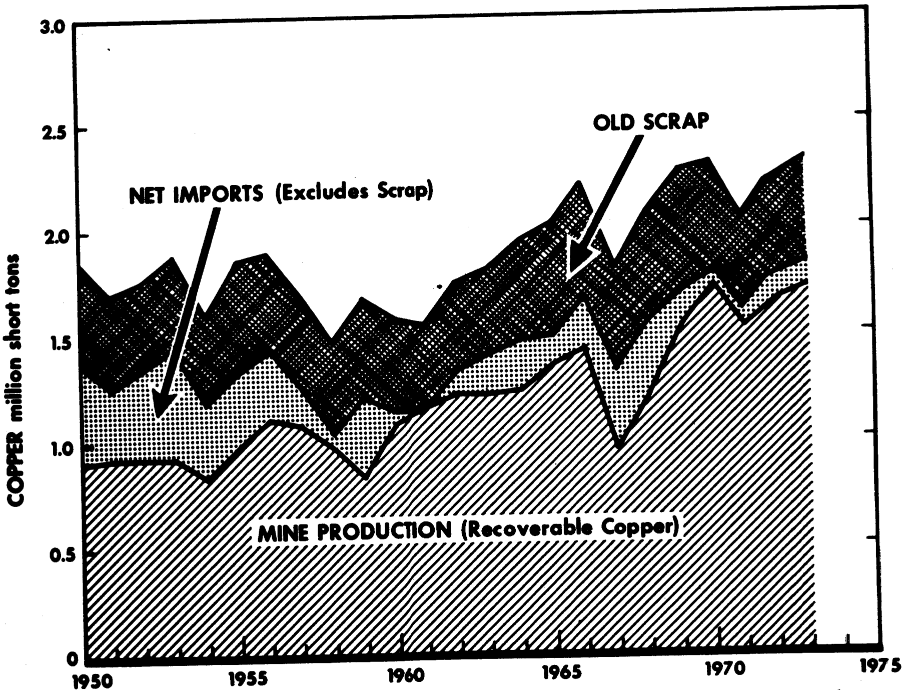

Figure 1.—Sources of copper supply for United States copper consumption.

produce at an annual rate of 24,000 tons. A modification of the copper concentrator at Butte was completed, increasing capacity from 40,000 to 50,000 tons of ore per day. The concentrator at Anaconda was reactivated to treat 14,000 tons of ore per day from the new Continental East pit. Production at the Yerington, Nev., property declined from 41,200 to 35,800 tons of copper. Development of the Victoria open pit mine and concentrator in eastern Nevada was initiated with production at an annual rate of 9,000 tons of copper in concentrates scheduled to start early in 1975. Exploration and feasibility planning continued toward development of a large underground mine at Carr Fork in the Bingham District of Utah.

Anamax Mining Company, formed January 1 as a joint venture of The Anaconda Company and American Metal Climax, Inc., operated the Twin Buttes, Ariz., open pit mine and produced 73,648 tons of copper in concentrates compared with 66,486 tons in 1972. A $200 million expansion program at Twin Buttes, including open pit expansion, an enlargement of the concentrator, and a leach-electrowinning plant for oxide ore, will increase capacity from 75,000 to 130,000 tons of copper with completion expected in 1975.

Kennecott Copper Corp. operated mines in Arizona, Nevada, New Mexico, and Utah; these mines produced a combined total of 471,700 tons of copper, compared with 460,600 tons in 1972. The Utah Copper Div. accounted for 255,000 tons of the total followed by the Ray Mines Div. (Arizona) with 98,900 tons, the Chino Mines Div. (New Mexico) with 67,800 tons, and the Nevada Mines Div. with 50,000 tons. Smelter capacity continued to be the limiting factor on Kennecott's mine production in 1973. At the Nevada Mines Div. replacement of flotation equipment to increase production was underway and will be completed by mid-1974. At the other operating divisions engineering studies to expand production capacities were in progress.

The American Smelting and Refining Company (Asarco) operated three copper mines in the vicinity of Tucson, Ariz. The Mission unit produced 46,600 tons of copper in concentrates compared with a 1972 output of 45,400 tons. Output at the Silver Bell unit increased slightly to 23,800 tons of copper in concentrates and precipitates. Production at the San Xavier mine as copper-bearing flux ore for use at Asarco's Hayden smelter and as precipitates from a new leach plant completed in May totaled 2,700 tons of copper. The new leach plant cost $12 million and has a design capacity to treat 4,000 tons per day of oxide ore that will yield approximately 12,000 tons of copper in precipitates per year. Construction work continued at the Sacaton mine at Casa Grande with an open pit mine and mill expected to be in operation early in 1974 and underground mining of deeper ore anticipated in 1979. The rated annual capacity of the Sacaton project is 21,000 tons of copper contained in concentrates.

Mines of the Phelps Dodge Corp. produced 319,600 tons of copper, a new record high that exceeded the previous 1970 record by 6,000 tons. The greater output reflected an increase at its Tyrone, N. Mex., operation from 78,800 to 104,000 tons which resulted from completion of an expansion program in July 1972. Production from the Arizona mines of Phelps Dodge declined from 226,200 to 215,300 tons. Of the total, 119,500 tons was produced at Morenci, 53,800 tons at Ajo, and 42,000 tons at Bisbee. The Bisbee open pit operations are expected to cease about mid-1974 owing to exhaustion of ore reserves and the underground operations are expected to continue at least through 1974 if copper prices are favorable. Removal of overburden and mill construction work continued at the Metcalf property near Morenci. This project has a rated capacity of 60,000 tons of copper per year with initial production planned for early 1975. Underground development work continued at Safford, Ariz., to determine the feasibility of mining a deep ore body containing an estimated 400 million tons of ore with an average grade of 0.72% copper. Reserves at producing mines and at the two properties under development were estimated at 1.9 billion tons of ore containing about 12 million tons of recoverable copper.

Cities Service Co., through its North American Chemicals and Metals Group, operated mines in Arizona and Tennessee that produced 39,600 tons of copper compared with 44,900 tons in 1972. Output from the Tennessee mines was reduced as a result of roasting and pelletizing problems encountered in early 1973 during startup operations of new facilities built for expansion of production. The 350 million ton, low-grade Pinto Valley copper deposit near Miami, Ariz., was under development with startup scheduled for mid-1974. A production rate of 40,000 tons of mill feed per day is expected by early 1975. Construction continued for underground mining from the high-grade Miami East ore body with production to start in 1975 and to reach a level of 2,000 tons of ore per day by 1978.

The White Pine, Mich., operations of White Pine Copper Co. milled a record 8,884,000 tons of copper ore averaging 1.0% copper with an 86.22% copper recovery in concentrate. Research on improved mining practices continued to be emphasized in an effort to reduce unit mining costs. One promising experiment was the use of a mobile crushing machine to reduce vehicle haulage and conveyor belt maintenance. With an average haul distance from the mine face to the mill of 3.3 miles in 1973 compared with 2.9 miles in 1972 it is apparent that haulage factors are becoming a more important cost consideration each year.

Magma Copper Co. operated the San Manuel and Superior mines in Arizona with a combined output of 158,300 tons of copper compared with 149,500 tons in 1972. At San Manuel the average daily production was a record high 61,553 tons of ore but somewhat below rated capacity owing to limitations in labor availability. At Superior the mine was shut down during July to enable transfer of haulage and hoisting operations to the new tunnel and shaft. By yearend mine production was near 3,000 tons of ore per day, about double the previous rate and the planned level of 3,300 tons is expected in 1974.

The Inspiration Consolidated Copper Co. operated open pit copper mines in the vicinity of Inspiration, Ariz.; 16.5 million tons of waste and 8.5 million tons of ore were mined for a combined record high 25 million tons of material handled. Approximately 6.7 million tons of the ore was treated in the concentrator with about 46% of the concentrator feed first processed in leaching tanks to recover acid soluble copper. The combined production was 43,134 tons of copper. Heap leaching of ore too low in copper content for in-plant treatment yielded an additional 8,198 tons of copper. In January, mining of the upper Ox Hide pit was almost completed and mining of the lower Ox Hide pit began. Copper production from the Ox Hide pits was 4,356 tons, a slight reduction from the previous year but the rate of production was increasing at yearend. At the Christmas open pit mine, southeast of Miami, Ariz., output was 9,508 tons, a 10% decline caused mostly by the lower copper content of ores treated. The ratio of waste removed per ton of ore mined rose from 4.94 to 5.77. Total mine production from all operating mines was 65,196 tons of copper.

Cyprus Mines Corp., through the Cyprus Pima Mining Co. (formerly Pima Mining Co.) operated the Pima mine near Tucson which produced 88,140 tons of copper in concentrates from milling 20.3 million tons of ore averaging 0.51% copper. The expanded plant facilities, including semi-autogenous grinding mills, completed early in 1973, resulted in increased capacity and reduced cost per ton. At yearend ore reserves were estimated at 221 million tons grading 0.49% copper. Exploration was in progress to test a mineralized area to the east and southeast of the present pit. The Cyprus Bruce Copper and Zinc Co. (formerly Bruce Mine Div.) operated its underground copper-zinc mine near Bagdad, Ariz., and produced about 3,000 tons of copper in concentrates from 93,000 tons of ore averaging 3.68% copper and 12.7% zinc. Reserves were estimated at 467,000 tons, sufficient for about 5 years of operation. The Cyprus Johnson Copper Company (formerly Johnson Camp Div.) is developing an oxide-copper ore deposit near Johnson, Ariz., with production scheduled for early 1975 at a rate of 4,000 tons of ore per day. Reserves were estimated at 14.7 million tons averaging 0.80% copper.

Cyprus Bagdad Copper Company, formed in 1973 by a merger of Cyprus Mines Corp. and Bagdad Mining Company, operated its Arizona mine and produced 12,000 tons of copper in concentrate and 7,133 tons as cathode copper, the latter obtained from oxide ore by a leach-electrowinning process. Sulfide ore mined in 1973 averaged 0.70% copper. A study was in progress to determine the feasibility of a major mine-mill expansion program and the possible construction of a smelter-refinery. Ore reserves for the expanded operation were estimated at 300 million tons averaging 0.49% copper with prospective additional reserves from exploration in progress.

Ranchers Exploration and Development Co. produced a record 7,382 tons of copper cathodes by a leaching-solvent extraction-electrowinning process at its Bluebird mine near Miami, Ariz. A fourfold enlargement of production capacity which would include a change from heap to vat or agitation leaching is under consideration. The in situ leaching operation at the Old Reliable deposit near San Manuel, Ariz., had an initial flow of copper-bearing solutions late in 1972 and by February 1973 output stabilized at about 250 tons of copper recovered in precipitates per month. Heap-leaching operations from mixed oxide-sulfide ore stockpiled during mining of high grade copper ore in 1970 at Ranchers' Big Mike mine near Winnemucca, Nev., yielded about 1,000 tons of cement copper. During the latter half of 1973 approximately 550,000 tons of copper ore and rock was blasted into the bottom of the old pit and the surface of the broken material was prepared for a leaching operation to recover copper from the copper-bearing solutions.

Hecla Mining Co. essentially completed the 7,500-foot twin 15-degree declines at its Arizona Lakeshore copper mine south of Casa Grande. Over 45,000 feet of underground openings have been driven and other facilities were under construction for a scheduled 1975 production with a designed capacity of 69,000 tons per year of copper. Poor ground conditions in the oxide ore body necessitated a change in plans to provide separate crushing facilities and hoisting of the ore through a vertical shaft instead of transfer by ore passes to the sulfide crushing-conveyor belt haulage system. Design engineering for the roast-leach-electrowinning plant, the oxide vat-leach plant, the sponge iron plant, and the byproduct sulfuric acid plant was in progress.

UV Industries Inc. operated its Continental mine near Bayard, N. Mex., and milled approximately 1,668,000 tons of copper ore compared with 875,000 tons in 1972. The increased quantity reflects completion of a mill expansion project. At yearend the company estimated ore reserves at 19.5 million tons of 2.0% copper amenable to underground mining plus 13.9 million tons of 0.8% copper amenable to open pit mining. An exploration program is planned to expand underground reserves both laterally and at greater depth.

Smelter Production.—Output of copper at primary smelters in the United States was 1.82 million tons, a 4% increase and a record high quantity for the second successive year. The record high was achieved despite some disruptions to production at several smelters caused by construction programs to modify existing facilities to meet air quality standards.

Asarco installed an anode casting plant at its Hayden, Ariz., smelter to eliminate casting blister copper cakes, previously remelted and cast into anodes at a refinery. A 1,000-foot smelter stack, the tallest in the country, was completed and when it becomes operational in 1974 the ambient-air quality will be improved by better dispersion of the weak sulfur dioxide gases that cannot be handled by the acid plant. At the El Paso, Tex., smelter a new sulfuric acid plant was dedicated in May and at the Tacoma, Wash., smelter a 200-ton-per-day liquid sulfur dioxide plant was under construction with startup scheduled for the spring of 1974.

Anaconda's smelter renovation program at Anaconda, Mont., to reduce emissions to the atmosphere and increase capacity from 30 million to 35 million pounds of copper per month was completed during the year. Construction of other facilities for dust control was underway. Kennecott had work in progress at its Hurley, N. Mex., smelter towards a mid-1974 completion of converter hoods, duct work, an electrostatic precipitator, and an acid plant; investigation of a low-fuel, direct smelting process was conducted on a pilot plant scale. At the McGill, Nev., smelter a 750-foot stack to improve dispersion of effluents was under construction; at the Hayden, Ariz., smelter an improved air quality control system, including an expanded acid plant and a computer monitored variable emissions control, was completed for full operation in 1974. A similar air quality monitoring network was placed in operation at the Garfield, Utah, smelter and construction was started on a new 1,200-foot smelter stack.

Phelps Dodge was constructing a new smelter in Hidalgo County, N. Mex., with a scheduled startup early in 1975. The facility will be required for treatment of concentrates from the Tyrone mine since the Morenci smelter presently handling the Tyrone output will be used to smelt concentrates from the new Metcalf mine. Cost of the new smelter project is estimated at $200 million, including $55 million for emission control facilities. It will be the first smelter in the United States to utilize the flash smelting process. At the Ajo, Ariz., smelter new emission control facilities, including a 600-ton-per-day sulfuric acid plant, were essentially completed. The company was about halfway through a $92 million program at the Morenci smelter which included a new reverberatory furnace, a ninth converter, waste heat boilers, electrostatic precipitators, and a 2,500-ton-per-day acid plant.

Magma Copper Co. experienced some output restrictions at its San Manuel, Ariz., smelter owing to anode casting problems and the necessity of installing water-cooled converter hoods as part of the air quality control program. An electrostatic precipitator and an acid plant were under construction and scheduled for operation in mid-1974. To provide a basis for comparison of conditions before and after installation of emission control facilities, an air monitoring network has been in operation for over a year.

Inspiration Consolidated Copper Co. essentially completed a $54 million construction program to replace much of its existing smelter at Miami, Ariz., and the facilities should become operational in 1974. The program replaced the reverberatory furnace with an electric furnace and the horizontal rotary converters with siphon-type converters, and it provides new sulfuric acid production facilities.

White Pine Copper Co. operated its slag recovery plant for the second year from April until the winter shutdown in December. The plant processed 881,000 tons of slag and recovered about 4.2 million pounds of copper for return to the smelter. Total 1973 smelter output was 157 million pounds of copper. It is estimated that 3 months of operation in 1974 will process all of the remaining slag.

Refined Production.—Production of refined copper from primary materials was 1.87 million tons, a slight decline from the record high of 1972. Refined copper produced from scrap was 465,100 tons compared with 423,243 tons in 1972. Total production of refined copper in the United States was 2.33 million tons, derived 80% from primary and 20% from scrap sources.

Asarco was constructing a new refinery of 420,000 tons of annual copper capacity at Amarillo, Tex., with completion scheduled for late 1975. This facility will replace the Baltimore refinery which will be phased out after 1975. Together with the necessary infrastructure and related facilities the new project will cost on the order of $100 million and will employ 700 people. At the Tacoma, Wash., refinery Asarco started construction of facilities for purifying the refining solution which will permit recovery of nickel salts.

Anaconda was enlarging its Great Falls, Mont., copper refinery to a capacity of 41 million pounds of cathode copper per month from the present 30 million pounds capacity.

Copper Sulfate.—Copper sulfate was produced from primary and/or secondary metal by companies with plants located as follows:

Company	Plant location
The Anaconda Company	Great Falls, Mont.
Chevron Chemical Co	Richmond, Calif.
Cities Service Co	Copperhill, Tenn.
Phelps Dodge Refining Corp.	Laurel Hill, N.Y.
	El Paso, Tex.
Van Waters & Rogers Inc	Wallace, Idaho.
	Midvale, Utah.
	Metaline Falls, Wash.

Copper sulfate production advanced 14% to 43,360 tons, the second successive increase following the slump in output during 1971. Shipments exceeded production and ending stocks were 4,580 tons. Of the total 44,090 tons shipped, producers' reports indicated that 19,840 tons was for agricultural uses, 23,220 tons was for industrial uses, and 1,030 tons was for other uses.

Phelps Dodge placed a new plant for producing copper sulfate from tankhouse electrolyte solutions at its El Paso copper refinery into operation.

Byproduct Sulfuric Acid.—Sulfuric acid was produced at eight copper smelters from the sulfur contained in offgases, and output increased for the 6th consecutive year from 1,010,600 to a record 1,088,300 tons, on a 100% acid basis. A 600-ton-per-day sulfuric acid plant was placed in operation during the year at the Anaconda, Mont., smelter of Anaconda. New sulfuric acid plants or expansions of existing plants were under construction at copper smelters at Ajo, Ariz., Hurley, N. Mex., Miami, Ariz., Morenci, Ariz., and San Manuel, Ariz.

SECONDARY COPPER AND BRASS

Domestic recovery of copper in all forms from all classes of purchased scrap totaled 1.36 million tons in 1973, a 5% increase from the 1972 total and the largest quantity since 1969. Recovery from copper-base scrap increased from 1.28 to 1.34 million tons. Brass mills accounted for 47% of the recovered copper, primary producers for 25%, and secondary smelters for 22%. The remaining 6% was reclaimed at chemical plants, foundries, and manufacturers.

Consumption of purchased copper-base scrap in 1973 was 1.86 million tons consisting of 63% new scrap and 37% old scrap. The major categories of brass mill products, refined copper, and brass and bronze ingots obtained from scrap all registered significant increases.

CONSUMPTION

Consumption of refined copper rose 7% to a record 2.40 million tons, reflecting the greater activity of the general economy. Wire mills accounted for 68% of refined copper consumption, brass mills for 30%, and all other consumer categories for the remaining 2%.

Apparent withdrawals of primary refined copper on domestic account was 1.70 million tons compared with 1.90 million tons in 1972.

STOCKS

Stocks of refined copper at primary producers decreased from 57,000 tons at the start of the year to 29,000 tons by the end of June, increased to 39,000 tons during July, trended down to 28,000 tons by the end of November, then rose to 37,000 tons by yearend. The trend of fabricators' stocks of copper in all forms was similar to that of the primary producers with stocks of 460,000 tons at the start of the year, drawn down to 419,000 tons by yearend.

PRICES

Domestic copper price quotations for electrolytic wirebar copper increased by 9½ cents per pound in three steps during the first quarter of 1973 to a quoted price of 60 to 60.25 cents per pound. Price controls prohibited any price increase between early

June and December 6 after which quotes were increased by approximately 8 cents to a range of 68.15 to 69.25 cents per pound. Prices on the London Metal Exchange increased from an average 50.7 cents per pound equivalent for January to 102.9 cents for November and then declined to 100.9 cents for December.

FOREIGN TRADE

U.S. exports of unmanufactured copper increased 18% to 277,600 tons. The largest category, refined copper, was 189,400 tons compared with 182,700 tons the preceding year. Exports of ore, concentrates, matte, and blister increased from 26,200 tons in 1972 to 30,900 tons and exports of copper scrap rose from 17,400 to 42,300 tons. Scrap exports were particularly large during June, July, and August following the domestic price ceilings imposed in early June and the escalation of foreign copper prices. Copper-base scrap was exempted from price controls, effective August 6, and there was a significant reduction in exports following this action.

U.S. imports of unmanufactured copper were 417,400 tons, a slight increase and the largest quantity since 1968. The largest category, refined copper, increased from 192,400 to 201,500 tons and the second largest category, blister copper, declined from 157,400 to 154,100 tons. Of the total imports Canada supplied 37%, Peru 24%, and Chile 14%.

WORLD REVIEW

World mine production of copper attained 7.86 million tons, an increase of 7% and a record high for the 6th consecutive year. All of the major producing countries except Peru and Zambia contributed to the increased output. Production from new mines or expansions to operating properties that were completed during 1972 and 1973 more than offset losses to production from strikes, political events, and transport difficulties.

The United States continued to lead the world in mine production with 22% of the total, followed by Canada with 11%, and Chile, Zambia, and the U.S.S.R. with 10% each.

Australia.—Mount Isa Mines, Ltd., operated its copper-lead-zinc-silver mine at Mount Isa and a copper smelter at Townsville to produce 129,300 tons of blister copper for the fiscal year ending June 30, 1973. An expansion program was completed by mid-1973 which gave a rated mine-mill-smelter productive capacity of 170,000 tons of copper per year. In the first 28 weeks of fiscal 1974, output of blister copper was 28% above the 1973 rate.

Mount Lyell Mining and Railway Co., Ltd., for the year ended June 30, 1973, produced a record 25,400 tons of copper in concentrate from 2.4 million tons of ore grading 1.19% copper mined and milled at its Tasmania operation. The transition of production from open pit to underground operations continued with 66% of production for the year from underground mining; compared with 41% in 1972. Reserves in all ore zones were estimated at 35 million tons of proven ore grading 1.48% copper and 10.6 million tons of probable ore grading 1.39% copper.

A joint Phelps Dodge Corp.-St. Joe Minerals Corp. exploration project on the Woodlawn deposit near Tarago, New South Wales, indicated 10 million tons of reserves averaging 1.5% copper, 3.0% lead, 7.5% zinc, and 1.5 ounces of silver per ton that may be minable by open pit methods. Pilot plant testing of bulk samples of the ore showed that processing will present considerable difficulties. Further drilling to test an indicated mineralized zone outside the proposed open pit limits is planned for 1974.

Botswana.—Bamangwato Concessions, Ltd. (BCL), brought its Selebi-Pikwe nickel-copper mining and smelting project into production in December, approximately 33 months after construction began. Initially, 2 million tons per year of ore from the Pikwe open pit and underground mines will yield about 17,000 tons of refined copper and 19,000 tons of refined nickel. In addition to the direct costs of the mining-smelting project, an estimated $82 million was expended by the Botswana Government to provide the needed infrastructure consisting of a dam on the Shashe River, a 50-mile-long water pipeline to the mine, a 50-megawatt coal-fired power station, a spur railroad track to the mine site, and a town for 12,000 people. Also there was an associated $4.5 million venture to provide a colliery and spur track to serve the smelter and power station.

The smelter product will be copper-nickel matte that will be refined at the American Metal Climax, Inc. (AMAX), rehabilitated nickel refinery at Braithwaite, La. A West German firm, Metallgesellschaft A.G., will purchase most of the copper production and more than half of the nickel output. Approximately 140,000 tons of byproduct sulfur will be marketed in southern Africa.

Ownership of BCL is 15% by the Government of Botswana and 85% by Botswana Roan Selection Trust, Ltd. (BRST), which in turn is owned 40% by the public and about 30% each by AMAX and the Anglo American Corp./Charter Consolidated Group.

A joint exploration project by Newmont Mining Corp., Tsumeb Corp., and United States Steel Corp. discovered moderate-grade copper intersections in a very large geologic structure.

Canada.—Production from mines that came onstream during 1972 and 1973 more than offset losses due to mine strikes and disruptions to rail transportation so that output rose 13% to 899,500 tons, a record high for the 4th successive year. British Columbia became the leading copper producing Province with 39% of the total followed by Ontario with 31%, Quebec 17%, Manitoba 8%, and the remaining Provinces, 5%.

Falconbridge Nickel Mines Ltd. operated nickel-copper mines and treatment plants in the Sudbury, Ontario, area during 1973 and metal deliveries of copper were 26,900 tons compared with 28,200 tons in 1972. Ore reserves at yearend were 93 million tons averaging 1.37% nickel and 0.68% copper. Falconbridge's Opemiska Div. mined and milled 1.1 million tons of 2.14% copper ore, which yielded 21,576 tons of copper in concentrate, compared with 1,074,000 tons of 2.3% copper ore in 1972. Ore reserves at yearend were 6.5 million tons with an average grade of 2.42% copper. The Lake Dufault Div. milled 555,000 tons of 3.65% copper to produce 18,890 tons of copper in concentrate. Reserves at yearend were estimated at 2.8 million tons grading 2.8% copper and 3.5% zinc.

Ecstall Mining Ltd., a subsidiary of Texasgulf Inc., mined 3.6 million tons of copper-lead-zinc-silver ore from the Kidd Creek mine near Timmins, Ontario, which yielded 205,600 tons of 25% copper concentrate and 1,300 tons of a copper-silver concentrate. Underground mining commenced in 1973 and by midyear supplied about 2,000 tons of ore per day, replacing an equivalent production from the open pit mine which will be phased out over the next few years. From start of operations in 1966 the mine has produced 25 million tons of ore averaging 1.53% copper. Remaining ore reserves above the 2,800-foot level are estimated at 95 million tons with a copper content somewhat above that previously mined. Deep drilling indicates a substantial tonnage of ore from the 2,800-foot level to well below the 4,000-foot level. A study is being made on the feasibility of constructing a copper smelter and electrolytic refinery with a capacity to produce 100,000 tons of copper per year from Kidd Creek concentrates.

The International Nickel Co. of Canada Ltd. (INCO) mined 19.7 million tons of nickel-copper ore from 16 mines in Ontario and Manitoba compared with 19 million tons from 14 mines in 1972. Improved grade control in mining operations increased the average grade from 1.33% nickel and 0.91% copper to 1.41% nickel and 0.98% copper. Copper deliveries from the Copper Cliff refinery were 163,560 tons with 154,090 tons in 1972. At yearend INCO estimated that proven ore reserves were 399 million tons containing 4.1 million tons of copper.

Noranda Mines Ltd. operated the Horne mine in Quebec and produced 550,000 tons of ore averaging 2.42% copper and 0.145 ounce of gold per ton. The mill treated 480,000 tons of sulfide ore and 130,000 tons of smelter slag which yielded 79,000 and 25,500 tons of copper concentrates, respectively. Sulfide ore reserves at yearend were 500,000 tons grading 2.40% copper, sufficient to maintain production into 1975. The company's Geco mine produced 1.5 million tons of copper-zinc-silver ore averaging 1.70% copper which yielded 22,900 tons of copper in concentrates. Output was curtailed by a 65-day strike which ended June 10 and by a shortage of skilled labor following the strike. Ore reserves at yearend were 29 million tons averaging 1.9% copper, 4.0% zinc, and 1.66 ounces of silver per ton. Noranda's smelter achieved a record high production of 260,000 tons of anode copper from smelting its own and custom concentrates. The Noranda Continuous Smelting Process prototype smelter, designed to treat 800 tons of copper concentrate per day, came onstream in midyear and contributed to the increased production.

Gaspé Copper Mines Ltd. operated the Needle Mountain and Copper Mountain mines and associated mills and smelter near Murdochville, Quebec. The Needle Mountain mine produced 11,400 tons of copper in concentrate from milling 1.2 million tons of ore averaging 1.12% copper. The Copper Mountain mine produced 22,730 tons of copper from milling 5.6 million tons of 0.56% copper ore. A new 22,500-ton-per-day sulfide concentrator started up in July and attained rated capacity in December. Feed to the smelter consisted of 107,400 tons from the Gaspé operation and 99,800 tons from custom sources for production of 49,300 tons of copper in anodes compared with 63,800 tons in 1972. The smelter was shutdown in May and June to install new equipment designed to increase annual capacity by 27,000 tons of blister copper. Startup difficulties hampered production and about 40,000 tons of concentrate were diverted for smelting elsewhere. The new acid plant was completed in December and the oxide ore leach plant is expected to be completed in the second quarter of 1974.

Madeleine Mines, Ltd., operated its copper mine and mill in Quebec, milling 714,000 tons of 1.31% copper ore to produce 8,797 tons of copper in concentrate. The shaft sinking project below the 2,720-foot level was completed and ore hoisting from the 2,400-foot level began in October. Reserves at yearend were 4.2 million tons with an average 1.1% copper content.

Hudson Bay Mining & Smelting Co., Ltd., operated nine mines along the Manitoba-Saskatchewan boundary and milled 1.8 million tons of ore to produce approximately 41,000 tons of copper in concentrates. The Centennial mine, whose discovery was announced in 1970, was under development in 1973. Exploration discovered a new ore body named the Western mine which is scheduled for development in 1974. Total ore reserves at yearend were 18 million tons with an average grade of 3.11% copper, 2.9% zinc, and 0.52 ounce of silver per ton.

Sheritt-Gordon Mines Ltd. operated the Fox, Lynn Lake, and Ruttan Lake mines in Manitoba with a combined output of 35,800 tons of copper in concentrates compared with 20,700 tons in 1972. The increase reflected the new Ruttan Lake copper-zinc open pit operation which commenced production in April. Shortage of skilled personnel and severe winter weather prevented achievement of the 10,000-ton-per-day rated capacity at the mine and mill on a sustained basis. The Lynn Lake nickel-copper mine had high production costs and continued operation is problematical.

The Granduc mine of Granduc Operating Co. north of Stewart, British Columbia, produced 33,500 tons of copper in concentrate from 2.8 million tons of ore grading 1.25% copper. An average 7,540 tons of ore was milled daily, the first year since operations started in 1970 that the design capacity of 7,000 tons was achieved. The sublevel caving system, the principal mining method, and an experimental cut-and-fill method are under analysis to improve efficiency and reduce dilution. Ore reserves, before dilution, are estimated at 33 million tons averaging 1.64% copper.

Similkameen Mining Co. Ltd., a subsidiary of Newmont Mining Corp., operated its mine near Princeton, British Columbia, at rates approaching the design capacity of 15,000 tons of ore per day. Output for the year was 20,600 tons of copper in concentrate from milling 5.4 million tons of 0.45% copper ore. Milling capacity is to be increased to 22,000 tons per day by early 1975 to enable treatment of material grading about 0.25% copper which is now mined and stockpiled. Ore reserves were estimated at 66 million tons averaging 0.53% copper.

Utah International Inc. shipped approximately 48,500 tons of copper in concentrate during the first full year of operation of its Island Copper mine on the northern end of Vancouver Island. The mill design capacity of 33,000 tons per day was exceeded by yearend after initial startup difficulties which required new equipment and modifications. Ore reserves were estimated at 280 million tons containing 0.52% copper and 0.025% molybdenum.

Brenda Mines Ltd. milled 8.9 million tons of ore averaging 0.20% copper and 0.06% molybdenum. This was 6% below that of 1972 and reflected the loss of production during a 40-day strike. Metal recoveries in concentrates were 89% for copper and 82% for molybdenum. An additional 2.8 million tons of low-grade ore was stockpiled for future treatment and 4.5 million tons of waste was stripped from the deposit.

Bethlehem Copper Corp. Ltd. mined a record 6.3 million tons of copper ore from open pit mines at Highland Valley, British Columbia, and produced concentrates containing 33,500 tons of copper. Proven ore reserves available to the present mill, including an extension south of the closed Jersey mine, total 61 million tons of 0.47% copper. Estimated reserves for other ore zones were 286 million tons of copper-molybdenum ore with an average grade of 0.43% copper and 0.017% molybdenum for the J-A ore body, 190 million tons of 0.48% copper for the Lake zone project, and at least 200 million tons of 0.40% copper equivalent for the Maggie ore zone.

Lornex Mining Corporation Ltd. began commercial production in October 1972 at its large, low-grade copper-molybdenum property in the Highland Valley of British Columbia and reached its mill design capacity of 38,000 tons of ore per day in March 1973. Approximately 14 million tons of ore were milled to produce 51,000 tons of copper and 1,740 tons of molybdenum in concentrates. The project was based on ore reserves estimated to be 293 million tons with an average grade of 0.427% copper and 0.014% molybdenum.

Gibralter Mines Ltd. during the first full year of operation at its copper-molybdenum deposit in the Cariboo District of British Columbia milled 15.1 million tons of ore at an average grade of 0.48% copper which yielded a total of 60,900 tons of copper in concentrate. The average daily throughput at the mill was 41,300 tons with a 83.4% copper recovery compared with 39,500 tons and 80.4%, respectively, during 1972.

Craigmont Mines Ltd. in the fiscal year ended October 31, 1973, produced 22,135 tons of copper in concentrate from 1.7 million tons of ore containing 1.38% copper from its mine near Merritt, British Columbia. Production was adversely affected by a strike at the mine, effective September 16 and output for the year was 6% below that of 1972.

Bell Copper Co. completed the first full year of production at its Babine Lake, British Columbia, property. Open pit mining consisted of 2.4 million tons of stripping, 1.0 million tons of low-grade ore stockpiled for future treatment, and 4.1 million tons of ore averaging 0.59% copper for delivery to the concentrator. The concentrator, with a rated capacity of 10,000 tons per day, averaged 11,270 tons and produced 77,800 tons of concentrate containing 20,300 tons of copper with an average 84.1% copper recovery.

Coast Copper Co., Ltd., suspended operations at its Benson Lake mine on northern Vancouver Island in November because of rising costs and unsatisfactory market conditions. During the 10 years of operations, 2.8 million tons of ore were mined to produce 157,000 tons of copper concentrate.

Chile.—Political turmoil associated with the military overthrow of the Allende Government in early September had a major impact on the copper industry in Chile. Problems of management, labor, and supply contributed to curtailment of production at levels far below the capacity that was available as a result of past substantial expansion programs. However, despite the disruptions, production for the year increased 2% to 818,800 tons of copper and by yearend the military junta, which had assumed operation of the Government, succeeded in increasing the annual rate of output to about 1,000,000 tons. If the problems of obtaining necessary foreign credits, replenishment of depleted supplies and equipment, and improvement in the general economy can be surmounted, the goal of achieving an output of approximately 1,000,000 tons may be attained in 1974. The Government indicated that the large copper mines, completely nationalized in 1971, will remain in that status but that the matter of compensation for the expropriated properties was subject to review.

Production from the large mines was as follows: Chuquicamata, 292,500 tons compared with 258,300 tons in 1972; El Teniente, 196,400 tons compared with 209,800 tons; El Salvador, 92,600 tons compared with 91,400 tons; Exótica, 35,100 tons, compared with 34,400 tons; and Andina, 61,900 tons compared with 59,400 tons.

Output at Chuquicamata was limited by a shortage of converter capacity at the smelter, and the developing instability of the pit walls may result in future mining problems. At El Teniente the shortage of water was being corrected and the associated Caletones smelter started up a third furnace in December to increase capacity to about 240,000 tons of copper per year. At Andina there were some initial rock mechanics difficulties in the block-caving mining system but by yearend the production goal of 65,000 tons per year was achieved.

British credit, contingent on insurance coverage, has been approved for construction of a new 220,000-ton-per-year smelter-refinery complex for El Salvador. A feasibility study was in progress for development of the large El Abra porphyry copper deposit about 45 miles northeast of Chuquicamata. Indicated reserves from preliminary drilling were 25 million tons of copper oxide ore underlain by 400 million tons of sulfide ore grading between 0.8% to 1.0% copper. Tentative plans would require a $450 million investment for a 330,000-ton-per-year copper facility to be placed in operation about 1980.

Cyprus.—The Cyprus Island Div. of Cyprus Mines Corp. operated open pit mines at Lefka and Skouriotissa and a pressure-leach plant for reprocessing of mill tailings. Output of copper contained in concentrates and precipitates totaled about 10,300 tons. Milled ore averaged 1.16% copper but reserves of this grade were exhausted during 1973. However, a deposit of lower grade in an adjoining area with reserves estimated to extend the life of the mining operations about 5 years was brought into production.

Indonesia.—Freeport Indonesia Inc., a subsidiary of Freeport Minerals Co., completed development of the 11,500-foot-high Ertsberg copper deposit in West Irian late in 1972 and the mine was considered operational on February 1, 1973. However, there were serious startup problems which required substantial modifications before the design capacity of 250,000 tons of copper concentrate per year was approached by yearend. Output for the year was 125,600 tons of concentrates containing 41,800 tons of copper plus quantities of gold and silver. The ore mined from the enriched upper part of the deposit averaged nearly 3.5% copper compared with the estimated ore reserve of 33 million tons averaging 2.5% copper; also 0.025 ounce gold and 0.265 ounce silver per ton.

Malaysia.—The Mamut Mines Development Co., a consortium of Japanese firms in a joint venture with the Sabah Government and other Malaysian interests, continued development of a copper deposit near Mamut, Sabah. Production is scheduled for early 1975 at a rate of 30,000 tons per year of copper in concentrate.

Mauritania.—Société Minière de Mauritanie (SOMIMA) operated their open pit copper oxide mine at Akjoujt and produced 23,450 tons of copper in concentrates, a 46% increase from 1972 but below the design capacity of about 30,000 tons of copper per year. The oxide ore is concentrated by use of the Torco segregation process.

Mexico.—Asarco Mexicana, S.A., increased the output of blister copper 3%, to 37,100 tons. Cía Mexicana de Cobre, 49% owned by Asarco Mexicana, continued plans toward construction of a 130,000- to 160,000-ton-per-year mine-mill-smelter-refinery complex to exploit a porphyry copper deposit at the La Caridad property near Nacozari in the State of Sonora. The deposit has an estimated ore reserve of 770 million tons grading 0.7% copper and 0.016% molybdenum.

Compañía Minera de Cananea, S.A., operated the Cananea mine and smelter to produce 45,412 tons of blister and refined copper compared with 44,574 tons in 1972. Production was hampered by mechanical problems in the metallurgical facilities. An expansion program in progress is designed to achieve an output of 70,000 tons of copper in 1976.

Panama.—Canadian Javelin Ltd. announced that exploration had disclosed reserves in excess of 2 billion tons of 0.8% copper ore in the Cerro Colorado project in western Panama. Feasibility studies to develop the ore body were in progress with a goal of 400,000 tons of copper production per year, half to be exported as concentrate and the remainder to be split between blister and refined copper. Copper exploration at the Petaquilla concession, about 90 miles east of the Cerro Colorado deposit, will be undertaken by Cobre Panama, a consortium of Japanese companies.

Papua New Guinea.—Bougainville Copper Pty., Ltd., in the first full year of operation of its open pit copper mine on Bougainville Island in the Territory of Papua New Guinea produced approximately 202,000 tons of copper in concentrate. Initial mining was in an enriched, mixed oxide-sulfide portion of the deposit. This large copper development, consisting of an open pit mine, a 90,000-ton-per-day concentrator, two towns, port facilities, a power station, and other ancillary facilities, has an annual rated productive capacity of 162,500 tons of copper in concentrate. The project is based on a porphyry copper deposit calculated to contain approximately

1 billion tons of ore grading 0.48% copper and 0.02 ounce of gold per ton.

Peru.—Production of Southern Peru Copper Corp., in terms of blister copper produced and export of copper in concentrates, was 133,500 tons compared with 148,300 tons in 1972. The reduced output was caused by strikes at both the Toquepala mine and the Ilo smelter. At the smelter 62 production days were lost compared with 43 days in 1972. Cerro Corp. mining-milling-smelting facilities were operated without interruptions and production of copper at its La Oroya smelter increased 10% to a record high 63,127 tons, with 46% of the output from purchased ores.

Progress on Southern Peru's Cuajone project in 1973 included stripping of 37 million tons of mine overburden, driving 24,800 feet of railroad tunnels, and start of construction on the concentrator, town sites, and other facilities. In November, Southern Peru concluded an agreement with a consortium of 29 United States, Canadian, European, and Japanese banks for a $200 million loan to help finance the project. Total cost of the project is estimated to be $550 million, and it is designed to have an annual output of 180,000 tons of blister copper, with production commencing late in 1976.

Compañía Minera del Madrigal, a subsidiary of Homestake Mining Co., processed 153,000 tons of ore at its Madrigal copper-lead-zinc mine in southern Peru during the first full year of operation. Ore grade averaged 1.8% copper, 3.2% lead, and 5.8% zinc. Approximately 26,000 tons of concentrates containing 7,600 tons of copper were produced and shipped to Japan.

Philippines.—Atlas Consolidated Mining & Development Corp., the largest copper producer in the Philippines, operated mines and mills on Cebu Island with a rated capacity of about 66,000 tons of ore per day. An expansion program was in progress to expand capacity to 100,000 tons of ore per day by early 1976. Atlas also planned to construct a 130,000-ton-yer-year smelter-refinery facility costing an estimated $148 million.

Marinduque Mining and Industrial Corp. planned an expansion program at its Sipalay copper mine on Negros Island from 13,500 to 18,000 tons per day of ore with completion scheduled for 1975. Benquet Consolidated began construction of the Tayson mine-mill, 20,000 tons of ore per day, project on Luzon Island with completion expected by the end of 1975. Philex Mining Corp. had an expansion program in progress to increase milling capacity at its operation near Tuba, Benquet Province, from 21,000 to 24,000 tons per day of ore. Western Minolco Corp. had under construction a 15,000-ton-per-day mining-milling project at its Boneng copper project near Baguio, Benquet Province, with initial output anticipated early in 1974.

Rhodesia, Southern.—M.T.D. Mangula Ltd. during the year ending September 30, 1973, produced 19,000 tons of copper in concentrates and precipitates from the Mangula mine about 80 miles northwest of Salisbury. Concentrates containing 16,000 tons of copper were produced from milling 1.3 million tons of sulfide ore and precipitates containing 3,000 tons of copper were produced from treating 440,000 tons of an oxidized ore in the leach plant. Proved sulfide ore reserves were 16.5 million tons averaging 1.27% copper and oxidized ore reserves amounted to 0.6 million tons of 0.72% oxide copper. The Norah and Silverside mines in the first full year of operation produced 2,600 and 2,200 tons of copper in concentrates, respectively. Proven sulfide ore reserves were 1.9 million tons of 1.35% copper at the Norah mine and 440,000 tons of 1.77% copper at the Silverside mine.

Lomagundi Smelting and Mining Ltd. produced 2,700 tons of copper in concentrate from mining and milling 300,000 tons of ore from the Alaska mine. The Shackleton mine yielded 9,700 tons of copper in concentrate from 610,000 tons of 1.68% copper ore. Proved reserves at yearend were 410,000 tons of 1.72% copper at the Alaska mine and 260,000 tons of 1.94% copper at the Shackleton mine. The Shackleton mine had an additional 2.9 million tons of probable ore averaging 1.99% copper.

Gwai River Mines Ltd. produced 1,700 tons of copper in concentrate from mining and milling 190,000 tons of 1.11% copper ore. Proved ore reserves were 260,000 tons of 1.12% copper.

South Africa, Republic of.—O'okiep Copper Co. Ltd. mined and milled 3.3 million tons of ore with an average grade of 1.34% copper which yielded 37,800 tons of blister copper compared with 40,700 tons in 1972. Ore reserves at O'okiep mines at the end of 1973 were estimated at 26.9 million tons averaging 1.58% copper. Exploration in progress indicated additional significant tonnages at deeper levels. An important development was the completion in October of an 80-mile pipeline from the Orange River to correct a water problem which has hampered operations in the past. O'okiep and the Tsumeb Corp. (South-West Africa) commissioned a feasibility study for a joint project to construct a 150,000-ton-per-year copper refinery at some suitable site in southern Africa to treat all of the blister copper production from their respective smelters.

Palabora Mining Co. Ltd. had a smelter production of 105,700 tons of copper, a 4% decline from 1972. Ore milled was 21.1 million tons of 0.57% copper compared with 21.3 million tons of 0.56% copper in 1972. Under the present plant the Palabora pit will have a life of about 16 to 18 years. Alternative plans are being studied to extend the pit life before conversion to underground mining occurs.

Messina (Transvaal) Development Co. mined and milled 1.27 million tons of 1.12% copper ore from its Messina mine which yielded 11,900 tons of copper in concentrate. The tonnage of proved ore reserves at yearend was estimated at 5.9 million tons averaging 1.45% copper.

Africa Triangle Mining Prospecting and Development Co. operated its copper-zinc mine near Prieska in northwestern Cape Province for the first full year following initial output in October 1972. Startup problems are expected to delay reaching the rated capacity of 250,000 tons of ore per month until about mid-1974. The development is based on an ore deposit with proven reserves estimated at 25 million tons grading between 1.5% to 2.0% copper and 3% zinc.

Phelps Dodge Corp. continued drilling and development work at two copper-lead-zinc-silver discoveries (Aggeneys project) about 3.5 miles apart in Cape Province. One deposit has an estimated 33 million tons of ore averaging 0.6% copper, 2.3% lead, 0.5% zinc, and 0.8 ounce of silver per ton that may be minable by open pit methods. In addition, possible reserves minable by underground methods were estimated at 53 million tons averaging 0.8% copper, 2.9% lead, 0.6% zinc, and 1.8 ounces of silver per ton. The other deposit has open pit reserves estimated at 41 million tons of 0.4% copper, 4.5% lead, 2.3% zinc, and 1.7 ounces of silver per ton and possible underground reserves of 28 million tons averaging 0.36% copper, 3.0% lead, 2.2% zinc, and 1.0 ounce of silver per ton.

South-West Africa, Territory of.—The Tsumeb Corp. Ltd. mined 494,000 tons of ore from the Tsumeb mine averaging 4.10% copper, 11.51% lead, and 2.65% zinc. At the Kombat mine 401,000 tons of ore grading 1.67% copper and 1.88% lead was mined. The Matchless mine, near Windhoek, was reopened in February and for 1973 produced 112,000 tons of ore averaging 2.23% copper. Smelter production at Tsumeb was 40,000 tons of blister compared with 28,800 tons in 1972 when feed to the smelter was reduced by a first quarter strike at the Tsumeb mine and a lower copper content in the ore from the Kombat mine. Tsumeb has contracted to custom-smelt additional copper concentrates from South-West Africa and is considering expanding its copper smelter to an annual productive capacity of 79,000 tons. Ore reserves as of the end of 1973 were estimated at 5.5 million tons assaying 4.68% copper, 8.52% lead, and 2.15% zinc for the Tsumeb mine; 1.3 million tons of 1.93% copper and 3.07% lead for the Kombat mine; and 1.0 million tons of 2.37% copper at the Matchless mine.

Oamites Mining Co. Ltd. operated the Oamites mine at capacity and produced 7,713 tons of copper in concentrate from milling 556,000 tons of 1.35% copper ore. A second decline from the surface and other development work accelerated output by 15% during the last quarter of 1973.

Uganda.—Kilembe Mines, Ltd., 70% owned by Falconbridge Nickel Mines Ltd. (Canada), processed 821,000 tons of ore to produce 10,000 tons of blister copper compared with 14,000 tons in 1972. Production was severely restricted in the latter half of the year due to numerous breakdowns in the electric furnace. There was also a scarcity of trained personnel and a supply problem. Ore reserves at yearend in the proven and probable category were estimated to be 5.8 million tons of 1.95% copper.

Zaire.—La Générale des Carrières et des Mines du Zaire (Gécamines), the Government-owned mining company, increased copper output 8% to 508,000 tons. A $250 million expansion program designed to increase production of copper to about 625,000 tons by 1978 was started. Included in the program were the opening of two open pit mines, a new concentrator, a flash smelting plant, and a refinery. An additional expansion is planned to increase capacity to about 660,000 tons copper output by 1980.

A joint Japanese corsortium, Zairian Government concern, Société de Développement Industriel et Minièr du Zaire (SODIMIZA), completed the first full year of operating the Mushoshi mine in Shaba Province. Technical difficulties continued to hamper production which was approximately 30,000 tons of copper contained in concentrates, about 70% of rated capacity. A second mine site at Kinsenda is in preliminary stages of development but a firm schedule for production has not been determined. Exploration was conducted at two other locations—Mokambo and Kilela-Balanda.

Société Minière de Tenke-Fungurume (SMTF), a consortium of companies which includes Amoco Minerals Co., Charter Consolidated Ltd., and Leon Tempelsman & Son Inc., continued feasibility studies on mining copper deposits in their concession area of Shaba Province. The mining-milling-refining complex with the related infrastructure for a production capacity of about 150,000 tons of copper per year is estimated to cost $500 million to $600 million. Production is planned for 1977 to coincide with completion of the Inga-Shaba power transmission line.

Zambia.—In January, Rhodesia closed the Zambia/Rhodesia border to Zambian imports, and the Government of Zambia decided to discontinue the use of routes through Rhodesia for all of its trade. A shift to alternate routes, chiefly an expansion of the road service to Dar es Salaam, Tanzania and Mombasa, Kenya and the rail route to Lobito, Angola caused little disruption in the export of copper. However, the reorganized routes for imports resulted in additional transport costs, delay in arrival of some supplies, and occasional spot shortages.

In August, the President of Zambia announced measures that will have a major impact on the copper mining industry. The provisions included redeeming outstanding external bonds issued in payment for the 51% ownership of the copper mines acquired by Zambia in 1970; making the dividends for minority owners subject to exchange control regulations; making the Minister of Zambia responsible for mines chairman of the two copper mining companies and having the Government appoint their managing directors; and establishing a new marketing company wholly owned by the Government.

Roan Consolidated Mines, Ltd. (RCM), operated the Mufulira, Chibuluma, Chambishi, Kalengwa, and Luanshya mines that produced 307,000 tons of refined copper in the year ended June 30, 1973, compared with 268,000 tons in the previous year. Rehabilitation of the Mufulira mine continued and by yearend was at 80% of the capacity prior to the 1970 cave-in and flooding.

Luanshya production continued to be hampered by poor ground conditions which both slowed the mining rate and increased dilution of the ore. The Baluba extension was brought into production in January but oxide ore from the upper levels caused handling and concentrating difficulties during the year. The Chibuluma mine also experienced mining problems and a lower ore grade. Exploration at Chibuluma West increased ore reserves by over 4 million tons and a new shaft to exploit this area is planned. At the Chambishi mine, a conveyor system from the open pit and additions to the crushing-concentrating plant were completed; also development for underground mining continued.

Nchanga Consolidated Copper Mines Ltd. (NCCM), through the Rokana, Chingola, and Konkola Divs., operated copper mines, a smelter, and a refinery. For the year ending March 31, 1973, output of refined copper increased 10% to 486,000 tons. Production in 1974 is projected to decline to about 455,000 tons as a consequence of production disruptions during implementation of an expansion program designed to achieve an annual rate of 550,000 tons by mid-1975. At the Rokana Div. construction of the oxide concentrator and development of the Mindola North open pit to provide feed to the concentrator were proceeding toward the scheduled yearend 1973 completion. The introduction of periodic current reversal in the refinery tankhouse to increase capacity was delayed due to technical problems but was expected to be operational late in 1973. At the Chingola Div. the Nchanga pit was extended to the east, the Chingola "C" pit was brought into production, and the "C" shaft deepening was completed. The leach precipitation plant operation was curtailed early in 1973 owing to a shortage of acid.

Initial output of the solvent extraction-ion exchange process plant began in August 1973 and was expected to be fully operational by mid-1974. The level of production, shaft sinking, and other underground developments continued at a satisfactory rate at Konkola despite difficult ground and water problems.

TECHNOLOGY

Articles published on copper resources included results of research on geologic comparisons for most producing porphyry copper deposits of South America;[2] a statistical analysis of physical dimensions and economic characteristics of 58 commercial porphyry deposits to provide assistance in exploration planning, engineering studies, and financial analysis;[3] and an evaluation, in terms of geologic parameters, of the apparent variation in copper, molybdenum, and gold in porphyry copper deposits.[4] Research was conducted on the phase relationships of the copper-antimony sulfide mineral, tetrahedrite.[5]

A study was made to evaluate the potential supply of copper from identified domestic resources that could be produced at various copper prices and the rates of return on the required capital investment.[6] Other mineral extraction studies included an estimate of production costs to mine a group of vein copper deposits in Alaska,[7] the influence of rock fracture patterns on the cavability of a copper ore,[8] a simulated in situ leaching technology for a deeply buried sulfide deposit,[9] and a description of the recovery of byproducts related to copper production.[10] Chemical and physical property analysis of tailings and mine waste at a copper mine were determined in a planned program to improve stabilization and revegetation of tailing dikes.[11]

Research related to copper pyrometallurgy included a study of oxidizing conditions during copper smelting to predict the optimum quantity of converter slag to be recycled to the reverberatory furnaces[12] and use of pure oxygen in an experimental furnace to produce blister copper and a concentrated SO_2 gas from copper sulfide concentrate.[13] The Smelter Control Research Association (SCRA) concluded from information obtained in its pilot plant studies and a review of commercial prototype systems in other industries that, at its present state of development, wet-limestone scrubbing is not a reliable process for removal of sulfur dioxide from copper reverberatory furnace gas. Accordingly, SCRA has decided to devote its future efforts to other processes that offer promise of greater reliability and better sulfur recoveries.

Research was conducted on recovering copper from scrap by preferential melting in molten salt baths,[14] by leaching in a cupric ammonium carbonate solution,[15] and by the use of cryogenic techniques.[16]

Tests, on an industrial scale, demonstrated the feasibility of using high-current densities of at least 480 amperes per square

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meter in electrowinning of copper.[17] An article reviewed the factors involved in the choices of using various reducing agents such as wood, ammonia, natural gas, and propane for production of fire-refined copper.[18]

Research on the use of hydrometallurgy to recover copper was reported in papers describing the mechanism of copper cementation on iron in an aqueous solution;[19] flash roasting of cement copper as part of a postulated process for refining cement copper by oxidation roasting, acid leaching, and electrowinning;[20] dissolution of copper sulfide minerals in an aqueous chlorine solution;[21] sulfation roasting of chalcopyrite concentrates, followed by a water or dilute acid leach;[22] dissociation of chalcopyrite into simple sulfides by heating with elemental sulfur to enhance selective leaching of the copper;[23] and use of a substituted quinoline reagent to extract copper from leach solutions of copper-nickel concentrates.[24]

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Table 2.—Copper produced from domestic ores, by source

(Thousand short tons)

Year	Mine	Smelter	Refinery
1969	1,545	1,547	1,469
1970	1,720	1,605	1,521
1971	1,522	1,471	1,411
1972	1,665	1,649	1,680
1973	1,718	1,705	1,698

Table 3.—Copper ore and recoverable copper produced, by mining method

(Percent)

Year	Open pit		Underground	
	Ore	Copper [1]	Ore	Copper [2]
1969	88	84	12	16
1970	89	84	11	16
1971	88	82	12	18
1972	85	80	15	20
1973	89	78	11	22

[1] Includes copper from dump leaching.
[2] Includes copper from in-place leaching.

Table 4.—Mine production of recoverable copper in the United States, by month

(Short tons)

Month	1972	1973
January	131,306	136,641
February	140,106	135,050
March	147,458	151,336
April	140,714	149,893
May	144,623	151,598
June	137,566	146,998
July	123,176	129,706
August	141,714	141,785
September	139,410	139,878
October	140,640	153,299
November	136,597	140,844
December	141,530	140,912
Total	1,664,840	1,717,940

Table 5.—Mine production of recoverable copper in the United States, by State

(Short tons)

State	1969	1970	1971	1972	1973
Arizona	801,363	917,918	820,171	908,612	927,271
California	1,129	2,308	515	598	369
Colorado	3,598	3,749	3,938	3,944	3,123
Idaho	3,332	3,612	3,776	2,942	3,625
Maine	1,320	2,703	2,510	1,220	1,107
Michigan	75,226	67,543	56,005	67,260	72,221
Missouri	12,664	12,134	8,445	11,509	10,273
Montana	103,314	120,412	88,581	123,110	132,466
Nevada	104,924	106,688	96,928	101,119	93,702
New Mexico	119,956	166,278	157,419	168,034	204,742
Pennsylvania	3,382	2,539	3,349	2,611	1,845
Tennessee	15,353	15,535	13,916	11,310	8,500
Utah	296,699	295,738	263,451	259,507	256,589
Other States [1]	2,319	2,500	3,179	3,064	2,107
Total	1,544,579	1,719,657	1,522,183	1,664,840	1,717,940

[1] Includes Oklahoma, Oregon, and Washington.

Table 6.—Twenty-five leading copper-producing mines in the United States in 1973, in order of output

Rank	Mine	County and State	Operator	Source of copper
1	Utah Copper	Salt Lake, Utah	Kennecott Copper Corp	Copper ore, copper precipitates, gold-silver ore.
2	San Manuel	Pinal, Ariz	Magma Copper Co	Copper ore.
3	Morenci	Greenlee, Ariz	Phelps Dodge Corp	Copper ore and copper precipitates.
4	Berkeley Pit	Silver Bow, Mont	The Anaconda Company	Do.
5	Tyrone	Grant, N. Mex	Phelps Dodge Corp	Do.
6	Ray Pit	Pinal, Ariz	Kennecott Copper Corp	Do.
7	Pima	Pima, Ariz	Pima Mining Co	Copper ore.
8	White Pine	Ontonagon, Mich	White Pine Copper Co	Do.
9	Sierrita	Pima, Ariz	Duval Sierrita Corp	Do.
10	Chino	Grant, N. Mex	Kennecott Copper Corp	Copper ore and copper precipitates.
11	Twin Buttes	Pima, Ariz	The Anaconda Company	Copper ore.
12	New Cornelia	do	Phelps Dodge Corp	Copper, gold-silver ores.
13	Inspiration	Gila, Ariz	Inspiration Consolidated Copper Co.	Copper ore and copper precipitates.
14	Mission	Pima, Ariz	American Smelting and Refining Co.	Copper ore.
15	Ruth Pit	White Pine, Nev	Kennecott Copper Corp	Do.
16	Yerington	Lyon, Nev	The Anaconda Company	Copper ore and copper precipitates.
17	Silver Bell	Pima, Ariz	American Smelting and Refining Co.	Do.
18	Butte Hill	Silver Bow, Mont	The Anaconda Company	Do.
19	Copper Cities	Gila, Ariz	Cities Service Co	Do.
20	Mineral Park	Mohave, Ariz	Duval Corp	Do.
21	Magma	Pinal, Ariz	Magma Copper Co	Copper ore.
22	Copper Queen	Cochise, Ariz	Phelps Dodge Corp	Do.
23	Continental	Grant, N. Mex	UV Industries, Inc	Do.
24	Bagdad	Yavapai, Ariz	Bagdad Copper Corp	Do.
25	Esperanza	Pima, Ariz	Duval Corp	Copper ore and copper precipitates.

Table 7.—Mine production of recoverable copper in 1973, by method of treatment

Method of treatment	Ore treated (thousand short tons)	Recoverable copper: Thousand pounds	Recoverable copper: Percent yield	Remarks
Copper ore:				
By concentration	272,688	2,893,091	0.53	See table 9.
By smelting	337	9,433	1.40	See table 10.
By leaching	16,973	[1] 165,788	.49	See table 11.
Total	289,998	3,068,312	.53	
Dump and in-place leaching	--	318,045	--	See table 11.
Miscellaneous from cleanup, tailings, and noncopper ores	--	49,523	--	--
Total	XX	3,435,880	XX	--

XX Not applicable.
[1] Includes 70,115,475 pounds of electrowon copper.

Table 8.—Copper ore shipped directly to smelters or concentrated in the United States, by State in 1973, with copper, gold, and silver content in terms of recoverable metal

State	Ore shipped or concentrated (thousand short tons)	Copper: Thousand pounds	Copper: Percent	Gold (troy ounces)	Silver (troy ounces)	Value of gold and silver per ton of ore
Arizona	164,194	1,601,927	0.49	101,923	7,130,066	$0.17
Colorado	1	53	4.53	26	15,568	42.37
Idaho	93	2,208	1.18	105	39,086	1.19
Michigan	8,884	144,442	.81	--	850,273	.24
Montana	18,977	220,314	.58	21,031	3,723,828	.61
Nevada	14,485	136,673	.47	39,354	463,634	.35
New Mexico	26,414	359,294	.68	13,245	974,838	.14
Tennessee [1]	1,323	17,000	.64	68	73,104	.15
Utah	38,504	416,414	.54	303,614	2,619,504	.95
Other States	150	4,199	1.41	--	20,561	.35
Total	273,025	2,902,524	.53	479,366	15,910,462	.32

[1] Copper-zinc ore.

Table 9.—Copper ore concentrated[1] in the United States, by State in 1973, with content in terms of recoverable copper

State	Ore concentrated (thousand short tons)	Recoverable copper content: Thousand pounds	Recoverable copper content: Percent
Arizona	163,915	1,593,082	0.49
Idaho	93	2,178	1.17
Michigan	8,884	144,442	.81
Montana	18,974	219,862	.58
Nevada	14,485	136,673	.47
New Mexico	26,359	359,252	.68
Tennessee [2]	1,323	17,000	.64
Utah	38,504	416,405	.54
Other States	151	4,197	1.39
Total	272,688	2,893,091	.53

[1] Includes following methods of concentration: "Dual process" (leaching followed by concentration); "LPF" (leach-precipitation-flotation); and froth flotation.
[2] Copper-zinc ore.

Table 10.—Copper ore shipped directly to smelters in the United States, by State in 1973, with content in terms of recoverable copper

State	Ore shipped to smelters: Short tons	Recoverable copper content: Pounds	Recoverable copper content: Percent
Arizona	278,955	8,844,059	1.59
Colorado	588	53,331	4.54
Idaho	524	30,381	2.90
Montana	2,843	452,335	7.96
New Mexico	54,500	41,975	[1] .04
Utah	31	9,348	15.08
Other States	46	1,219	1.32
Total	337,487	9,432,648	1.40

[1] Primarily smelter fluxing material.

Table 11.—Copper precipitates (from dump or in-place leaching) shipped directly to smelters and copper ore leached (heap, vat, or tank) in the United States, by State in 1973, with content in terms of recoverable copper

State	Precipitates shipped (short tons)	Recoverable copper content (pounds)	Ore leached (short tons)	Recoverable copper content (pounds)	Percent
Arizona	80,511	119,057,841	9,411,507	[1] 126,650,951	0.67
Montana	28,977	44,338,703	--	--	--
Nevada	12,601	17,757,186	7,243,449	31,791,952	.22
New Mexico	31,311	48,952,027	--	--	--
Utah	54,479	87,865,914	318,481	7,345,116	1.15
Other States	58	73,315	--	--	--
Total	207,937	318,044,986	16,973,437	165,788,019	.49

[1] Includes 70,115,475 pounds of electrowon copper.

Table 12.—Copper ore smelted and copper ore concentrated in the United States, and average yield in copper, gold, and silver

Year	Smelting ore		Concentrating ore		Total				
	Thousand short tons	Yield in copper, percent	Thousand short tons [1] [2]	Yield in copper, percent	Thousand short tons [1]	Yield in copper, percent	Yield per ton in gold, ounce	Yield per ton in silver, ounce	Value per ton in gold and silver
1969	485	2.17	204,704	0.62	223,752	0.60	0.0028	0.065	0.23
1970	542	3.51	235,586	.60	257,729	.61	.0023	.067	.20
1971	453	1.76	222,121	.56	242,656	.55	.0022	.059	.18
1972	484	1.68	248,663	.55	266,831	.55	.0019	.059	.21
1973	337	1.40	272,688	.53	289,998	.53	.0018	.058	.32

[1] Includes some ore classed as copper-zinc and minor amount of tailings (1971 excludes tailings).
[2] Excludes tank or vat and heap leaching. (See tables 7 and 11).

Table 13.—Copper produced by primary smelters in the United States

(Short tons)

Year	Domestic	Foreign	Secondary	Total
1969	1,547,496	37,995	77,329	1,662,820
1970	1,605,265	36,073	78,897	1,720,235
1971	1,470,815	29,181	66,333	1,566,329
1972	1,649,130	41,263	69,017	1,759,410
1973	1,705,065	38,898	77,815	1,821,778

Table 14.—Primary and secondary copper produced by primary refineries in the United States

(Short tons)

	1969	1970	1971	1972	1973
PRIMARY					
From domestic ores, etc.:[1]					
Electrolytic	1,296,749	1,359,751	1,274,084	1,520,943	1,536,819
Lake	76,417	66,091	57,218	70,025	78,179
Casting	95,723	95,341	79,221	89,444	83,339
Total	1,468,889	1,521,183	1,410,523	1,680,412	1,698,337
From foreign ores, etc.:[1]					
Electrolytic	225,714	215,088	167,213	160,781	159,786
Casting and best select	48,212	28,823	14,046	32,040	10,365
Total refinery production of primary copper	1,742,815	1,765,094	1,591,782	1,873,233	1,868,488
SECONDARY					
Electrolytic[2]	410,749	433,394	323,913	341,581	377,523
Casting	2,094	17,623	18,599	16,667	14,290
Total secondary	412,843	451,017	342,512	358,248	391,813
Grand total	2,155,658	2,216,111	1,934,294	2,231,481	2,260,301

[1] The separation of refined copper into metal of domestic and foreign origin is only approximate, as accurate separation is not possible at this stage of processing.
[2] Includes copper reported from foreign scrap.

Table 15.—Copper cast in forms at primary refineries in the United States

	1972		1973	
	Thousand short tons	Percent	Thousand short tons	Percent
Billets	118	5	133	6
Cakes	124	6	147	6
Cathodes	552	24	584	26
Ingots and ingot bars	218	10	196	9
Wire bars	1,181	53	1,179	52
Other forms	38	2	21	1
Total	2,231	100	2,260	100

Table 16.—Production, shipments, and stocks of copper sulfate

(Short tons)

Year	Production		Shipments	Stocks Dec. 31[1]
	Quantity	Copper content		
1969	50,568	12,642	49,556	4,248
1970	45,352	11,338	40,324	8,812
1971	34,648	8,662	36,852	5,936
1972	38,052	9,513	37,964	5,828
1973	43,360	10,840	44,092	4,580

[1] Some small quantities are purchased and used by producing companies, so that the figures given do not balance exactly.

Table 17.—Byproduct sulfuric acid[1] (100% basis) produced in the United States

(Short tons)

Year	Copper plants[2]	Lead and zinc plants[3]	Total
1969	685,775	1,086,938	1,772,713
1970	747,784	1,090,817	1,838,601
1971	803,284	971,946	1,775,230
1972	1,010,614	859,103	1,869,717
1973	1,088,322	[4] 966,128	2,054,450

[1] Includes acid from foreign materials.
[2] Excludes acid made from pyrites concentrates in Arizona, Montana, Tennessee, and Utah.
[3] Excludes acid made from native sulfur.
[4] Includes 146,591 tons produced at lead plants.

Table 18.—Secondary copper produced in the United States

(Short tons)

	1969	1970	1971	1972	1973
Copper recovered as unalloyed copper	514,593	521,137	429,095	447,409	484,623
Copper recovered in alloys [1]	860,900	726,465	771,025	853,564	827,682
Total secondary copper	1,375,493	1,247,602	1,200,120	1,300,973	1,312,305
Source:					
New scrap	800,603	743,531	754,963	842,779	870,464
Old scrap	574,890	504,071	445,157	458,194	441,841
Percentage equivalent of domestic mine output	89	73	79	78	79

[1] Includes copper in chemicals, as follows: 1969—3,824; 1970—2,525; 1971—3,206; 1972—3,036; and 1973—3,704.

Table 19.—Copper recovered from scrap processed in the United States by kinds of scrap and form of recovery

(Short tons)

Kind of scrap	1972	1973	Form of recovery	1972	1973
New scrap:			As unalloyed copper:		
Copper-base	829,819	856,132	At primary plants	358,248	391,813
Aluminum-base	12,799	14,187	At other plants	89,161	92,810
Nickel-base	146	131	Total	447,409	484,623
Zinc-base	15	14			
Total	842,779	870,464	In brass and bronze	815,191	783,399
Old scrap:			In alloy iron and steel	2,791	2,712
Copper-base	451,490	435,109	In aluminum alloys	32,346	37,581
Aluminum-base	6,200	5,939	In other alloys	198	286
Nickel-base	400	741	In chemical compounds	3,038	3,704
Tin-base	10	10			
Zinc-base	94	42	Total	853,564	827,682
Total	458,194	441,841	Grand total	1,300,973	1,312,305
Grand total	1,300,973	1,312,305			

Table 20.—Copper recovered as refined copper, in alloys and in other forms from copper-base scrap processed in the United States

(Short tons)

Recovered by—	From new scrap		From old scrap		Total	
	1972	1973	1972	1973	1972	1973
Secondary smelters	64,135	68,652	229,322	218,903	293,457	287,555
Primary copper producers	211,711	204,106	146,537	122,855	358,248	326,961
Brass mills	535,643	562,291	32,435	44,500	568,078	606,791
Foundries and manufacturers	17,797	20,434	40,639	46,121	58,436	66,555
Chemical plants	533	649	2,557	2,730	3,090	3,379
Total	829,819	856,132	451,490	435,109	1,281,309	1,291,241

Table 21.—Production of secondary copper and copper-alloy products in the United States
(Short tons)

Item produced from scrap	1972	1973
UNALLOYED COPPER PRODUCTS		
Refined copper by primary producers	358,248	391,813
Refined copper by secondary smelters	64,995	73,310
Copper powder	24,073	19,438
Copper castings	93	62
Total	447,409	484,623
ALLOYED COPPER PRODUCTS		
Brass and bronze ingots:		
Tin bronzes	40,994	41,949
Leaded red brass and semired brass	154,607	149,165
High-leaded tin bronze	26,803	29,368
Yellow brass	21,027	20,857
Manganese bronze	10,596	12,126
Aluminum bronze	7,117	6,963
Nickel silver	3,657	3,744
Silicon bronze and brass	4,071	4,586
Copper-base hardeners and master alloys	11,041	15,724
Total	279,913	284,482
Brass-mill products	732,502	764,372
Brass and bronze castings	36,244	36,570
Brass powder	560	906
Copper in chemical products	3,038	3,704
Grand total	1,499,666	1,574,657

Table 22.—Composition of secondary copper-alloy production
(Short tons)

	Copper	Tin	Lead	Zinc	Nickel	Aluminum	Total
Brass and bronze production:[1]							
1972	210,082	19,106	16,203	33,906	560	56	279,913
1973	223,217	12,530	17,968	29,357	1,309	101	284,482
Secondary metal content of brass-mill products:							
1972	568,081	498	3,609	156,158	4,112	44	732,502
1973	600,543	488	3,584	149,188	10,470	99	764,372
Secondary metal content of brass and bronze castings:							
1972	29,942	1,030	2,450	2,758	7	57	36,244
1973	30,422	1,026	2,330	2,711	6	75	36,570

[1] About 93% from scrap and 7% from other than scrap.

Table 23.—Stocks and consumption of purchased copper scrap in the United States in 1973

(Short tons)

Class of consumer and type of scrap	Stocks Jan. 1	Receipts	Consumption: New scrap	Consumption: Old scrap	Consumption: Total	Stocks Dec. 31
SECONDARY SMELTERS						
No. 1 wire and heavy copper	1,992	28,123	4,892	23,166	28,058	2,057
No. 2 wire, mixed heavy and light copper	3,195	77,128	21,942	55,427	77,369	2,954
Composition or red brass	3,850	79,226	18,672	60,497	79,169	3,907
Railroad-car boxes	354	2,445	--	2,395	2,395	404
Yellow brass	5,214	60,620	7,357	53,134	60,491	5,343
Cartridge cases and brass	69	115	--	144	144	40
Auto radiators (unsweated)	2,935	58,919	--	58,220	58,220	3,634
Bronze	2,179	28,039	4,820	23,324	28,144	2,074
Nickel silver and cupronickel	639	4,664	582	4,099	4,681	622
Low brass	676	3,005	2,544	815	3,359	322
Aluminum bronze	137	904	817	100	917	124
Low-grade scrap and residues	9,028	63,175	49,289	9,887	59,176	13,027
Total	30,268	406,363	110,915	291,208	402,123	34,508
PRIMARY PRODUCERS						
No. 1 wire and heavy copper	3,076	128,679	64,048	64,883	128,931	2,824
No. 2 wire, mixed heavy and light copper	3,908	199,981	150,895	44,917	195,812	8,077
Refinery brass	28,761	5,513	3,812	1,300	5,112	18,193
Low-grade scrap and residues		263,006	91,520	182,455	273,975	
Total	35,745	597,179	310,275	293,555	603,830	29,094
BRASS MILLS [1]						
No. 1 wire and heavy copper	8,168	228,083	189,041	39,042	228,083	16,661
No. 2 wire, mixed heavy and light copper	1,709	60,275	58,407	1,868	60,275	3,886
Yellow brass	16,973	340,110	340,110	--	340,110	20,959
Cartridge cases and brass	7,412	88,909	83,112	5,797	88,909	5,607
Bronze	732	5,492	5,492	--	5,492	869
Nickel silver and cupronickel	5,589	28,208	28,208	--	28,208	3,717
Low brass	6,538	25,315	25,315	--	25,315	4,434
Aluminum bronze	123	322	322	--	322	9
Total [1]	47,244	776,714	730,007	46,707	776,714	56,142
FOUNDRIES, CHEMICAL PLANTS, AND OTHER MANUFACTURERS						
No. 1 wire and heavy copper	2,464	37,757	13,203	23,295	36,498	3,723
No. 2 wire, mixed heavy and light copper	1,202	13,151	3,819	9,091	12,910	1,443
Composition or red brass	1,065	5,247	2,650	2,873	5,523	789
Railroad-car boxes	927	6,273	--	7,032	7,032	168
Yellow brass	653	4,785	2,278	2,496	4,774	664
Auto radiators (unsweated)	988	11,118	--	10,524	10,524	1,582
Bronze	196	877	174	765	939	134
Nickel silver and cupronickel	3	4	--	6	6	1
Low brass	28	770	322	423	745	53
Aluminum bronze	59	720	302	422	724	55
Low-grade scrap and residues	194	1,009	230	557	787	416
Total	7,779	81,711	[2] 22,978	[2] 57,484	[2] 80,462	9,028
GRAND TOTAL						
No. 1 wire and heavy copper	15,700	422,642	271,184	150,386	421,570	25,265
No. 2 wire, mixed heavy and light copper	10,014	350,535	235,063	111,303	346,366	16,360
Composition or red brass	4,915	84,473	21,322	63,370	84,692	4,696
Railroad-car boxes	1,281	8,718	--	9,427	9,427	572
Yellow brass	22,840	405,515	349,745	55,630	405,375	26,966
Cartridge cases and brass	7,481	89,024	83,112	5,941	89,053	5,647
Auto radiators (unsweated)	3,923	70,037	--	68,744	68,744	5,216
Bronze	3,107	34,408	10,486	24,089	34,575	3,077
Nickel silver and cupronickel	6,231	32,876	28,790	4,105	32,895	4,340
Low brass	7,242	29,090	28,181	1,238	29,419	4,809
Aluminum bronze	319	1,946	1,441	522	1,963	188
Low-grade scrap and residues [3]	37,983	332,703	144,851	194,199	339,050	31,636
Total	121,036	1,861,967	1,174,175	688,954	1,863,129	128,772

[1] Brass-mill stocks include home scrap; purchased scrap consumption assumed equal to receipts, so lines in brass-mill and grand total sections do not balance.
[2] Of the totals shown, chemical plants reported the following: Unalloyed copper scrap, 681 tons new and 2,857 tons old.
[3] Includes refinery brass.

Table 24.—Consumption of copper and brass materials in the United States by principal consuming group

(Short tons)

Year and item	Primary producers	Brass mills	Wire mills	Foundries, chemical plants, and miscellaneous users	Secondary smelters	Total
1972:						
Copper scrap	533,729	746,764	--	71,699	429,082	1,781,274
Refined copper [1]	--	667,218	1,526,296	35,400	9,953	2,238,867
Brass ingot	--	16,691	--	[2]284,581	--	301,272
Slab zinc	--	179,781	--	2,613	9,435	191,829
Miscellaneous	--	--	--	200	10,016	10,216
1973:						
Copper scrap	603,830	776,714	--	80,462	402,123	1,863,129
Refined copper [1]	--	714,438	1,672,255	39,760	10,595	2,437,048
Brass ingot	--	14,473	--	[2]285,531	--	300,004
Slab zinc	--	185,878	--	3,137	8,635	197,650
Miscellaneous	--	--	--	200	12,987	13,187

[1] Detailed information on consumption of refined copper will be found in table 28.
[2] Shipments to foundries by smelters plus decrease in stocks at foundries.

Table 25.—Foundry consumption of brass ingot, by type, in the United States

(Short tons)

	1969	1970	1971	1972	1973
Tin bronzes	43,772	47,474	44,279	52,365	61,254
Leaded red brass and semired brass	155,895	128,798	132,474	148,182	139,649
High-leaded tin bronze	20,278 }	79,960	107,700	114,332	133,493
Yellow brass	32,998 }				
Manganese bronze	10,680	14,545	8,555	10,229	11,262
Hardeners and master alloys	4,315	5,196	5,545	7,257	6,879
Nickel silver	4,041	3,265	3,466	2,838	2,908
Aluminum bronze	8,498	7,903	7,478	6,947	8,483
Total	280,477	287,141	309,497	342,150	363,928

Table 26.—Foundry consumption of brass ingot by types, refined copper, and copper scrap, in the United States in 1973, by geographic division and State

(Short tons)

Geographic division and State	Tin bronzes	Leaded red brass and semi-red brass	High leaded tin bronze	Yellow brass	Man-ganese bronze	Hardeners and master alloys	Nickel silver	Alumi-num bronze	Total brass ingot	Refined copper con-sumed	Copper scrap con-sumed
New England:											
Connecticut	791	3,766	93	1,064	66			400	6,185	598	753
Massachusetts	1,822	5,543	243	481	360	47	375	24	8,703	480	72
Maine, New Hampshire, Rhode Island, Vermont	136	2,321	73	230	257			41	3,245	12	--
Total	2,749	11,630	409	1,775	683	47	375	465	18,133	1,090	825
Middle Atlantic:											
New Jersey	781	1,796	66	220	216	8	87	91	3,265	2,935	2,961
New York	4,998	4,241	832	633	1,306	143	235	240	12,628	1,983	3,728
Pennsylvania	8,446	12,682	1,264	1,696	861	1,399	510	1,464	28,322	6,271	6,626
Total	14,225	18,719	2,162	2,549	2,383	1,550	832	1,795	44,215	11,189	13,315
East North Central:											
Illinois	3,329	18,158	688	810	840	305	25	1,069	25,224	1,610	3,424
Indiana	996	11,102	453	722	281	2,144	284	49	16,031	1,185	9,917
Michigan	27,495	12,162	[1] 9,882	W	2,221	678	10	2,280	169,533	9,868	1,113
Ohio		13,086			1,310		12	545		3,228	9,529
Wisconsin	1,074	8,636	2,223	1,621	168	1,375	453	265	15,815	5,377	975
Total	32,894	63,144	[1] 116,251	[2] W	4,820	4,502	784	4,208	226,603	21,268	24,958
West North Central:											
Iowa, Kansas, Minnesota	325	5,545	79	286	854	68	21	136	7,308	338	1,721
Missouri, Nebraska, South Dakota	222	1,179	598	1,347	330			72	3,754	164	2,360
Total	547	6,724	677	1,633	1,184	68	21	208	11,062	502	4,081
South Atlantic:											
Delaware, District of Columbia, Florida, Georgia, Maryland	798	1,059	--	170	141	2	494	139	2,803	389	314
North Carolina, South Carolina, Virginia, West Virginia	3,136	4,933	319	474	136	191	1	200	9,220	564	3,895
Total	3,934	5,992	319	474	277	193	495	339	12,023	953	4,209
East South Central:											
Alabama, Kentucky, Mississippi, Tennessee	2,361	12,222	1,057	1,075	627	84	149	39	17,614	1,737	11,879
West South Central:											
Arkansas, Louisiana, Oklahoma, Texas	2,145	3,841	376	2,654	395	19	149	1,006	10,585	1,313	1,907

Mountain:											
Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah	219	297	6	42	118	3	--	8	693	122	644
Pacific:											
California	1,856	16,932	113	1,913	666	85	94	261	21,920	32	12,439
Oregon and Washington	324	148	7	1	109	328	9	154	1,080	329	2,667
Total	2,180	17,080	120	1,914	775	413	103	415	23,000	361	15,106
Grand total	61,254	139,649	[1] 133,493	[2] W	11,262	6,879	2,908	8,483	363,928	38,535	76,924

W Withheld to avoid disclosing individual company confidential data.
[1] Total includes yellow brass.
[2] Total includes high-leaded tin bronze.

Table 27.—Primary refined copper supply and withdrawals on domestic account

(Short tons)

	1969	1970	1971	1972	1973
Production from domestic and foreign ores, etc	1,742,815	1,765,094	1,591,782	1,873,233	1,868,488
Imports [1]	131,171	132,143	163,988	192,379	201,513
Stocks Jan. 1 [1]	48,000	39,000	130,000	75,000	57,000
Total available supply	1,921,986	1,936,237	1,885,770	2,140,612	2,127,001
Copper exports [1]	200,269	221,211	187,654	182,743	189,396
Stocks Dec. 31 [1]	39,000	130,000	75,000	57,000	37,000
Total	239,269	351,211	262,654	239,743	226,396
Apparent withdrawals on domestic account [2]	1,683,000	1,585,000	1,623,000	1,901,000	1,901,000

[1] May include some copper refined from scrap.
[2] Includes copper delivered by industry to the Government stockpiles.

Table 28.—Refined copper consumed by class of consumers

(Short tons)

Year and class of consumer	Cathodes	Wire bars	Ingots and ingot bars	Cakes and slabs	Billets	Other	Total
1972:							
Wire mills	222,894	1,295,401	W	W	W	8,001	1,526,296
Brass mills	192,263	34,402	119,710	160,201	160,642	--	667,218
Chemical plants	--	--	35	--	--	819	854
Secondary smelters	5,602	W	4,129	--	W	222	9,953
Foundries	2,790	1,494	9,705	W	W	1,236	15,225
Miscellaneous [1]	1,789	632	7,860	312	797	7,931	19,321
Total	425,338	1,331,929	141,439	160,513	161,439	18,209	2,238,867
1973:							
Wire mills	334,317	1,315,130	W	W	W	22,808	1,672,255
Brass mills	186,110	37,985	124,147	193,094	172,752	350	714,438
Chemical plants	--	--	23	--	--	1,202	1,225
Secondary smelters	6,193	--	4,212	W	W	190	10,595
Foundries	2,230	1,241	10,425	W	W	905	14,801
Miscellaneous [1]	2,375	1,675	8,992	351	1,909	8,432	23,734
Total	531,225	1,356,031	147,799	193,445	174,661	33,887	2,437,048

W Withheld to avoid disclosing individual company confidential data; included in "Other."
[1] Includes iron and steel plants, primary smelters producing alloys other than copper, consumers of copper powder and copper shot, and miscellaneous manufacturers.

Table 29.—Stocks of copper at primary smelting and refining plants in the United States, Dec. 31

(Thousand short tons)

Year	Refined copper [1]	Blister and materials in process of refining [2]
1969	39	291
1970	130	340
1971	75	303
1972	57	281
1973	37	265

[1] May include some copper refined from scrap.
[2] Includes copper in transit from smelters in the United States to refineries therein.

Table 30.—Stocks of copper in fabricators' hands Dec. 31

(Short tons)

Year	Stocks of refined copper [1] (1)	Unfilled purchases of refined copper from producers (2)	Working stocks (3)	Unfilled sales to customers (4)	Excess stocks over orders booked [2]
1969	502,300	99,232	412,734	256,299	−67,501
1970	515,096	86,925	438,925	156,007	7,089
1971	510,810	96,209	431,348	187,688	−12,017
1972	460,062	91,845	392,920	178,121	−19,134
1973	419,006	87,590	373,506	296.574	−163,484

[1] Includes in-process metal and primary fabricated shapes. Also includes small quantities of refined copper held at refineries for fabricators' account.
[2] Columns (1) plus (2) minus (3) and minus (4) equal column (5).

Source: United States Copper Association.

Table 31.—Dealers' monthly average buying price for copper scrap and consumers' alloy-ingot prices at New York in 1973

(Cents per pound)

Grade	Jan.	Feb.	Mar.	Apr.	May	June
No. 2 copper scrap	31.84	35.68	42.93	44.21	44.50	46.50
No. 1 composition scrap	32.50	33.29	37.45	40.21	40.50	40.50
No. 1 composition ingot	52.87	56.56	62.41	63.33	63.50	63.69

Grade	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
No. 2 copper scrap	46.50	52.07	58.50	61.77	68.26	66.50	49.80
No. 1 composition scrap	40.50	41.54	44.50	45.32	48.40	48.70	40.87
No. 1 composition ingot	63.50	69.21	72.25	72.39	75.92	76.55	66.02

Source: Metal Statistics, 1974.

Table 32.—Average monthly quoted prices of electrolytic copper for domestic delivered, in the United States and for spot copper at London

(Cents per pound)

Month	1972			1973		
	Domestic delivered		London spot [1] Metals Week	Domestic delivered		London spot [1] Metals Week
	American Metal Market	Metals Week		American Metal Market	Metals Week	
January	50.38	50.32	48.84	52.41	52.39	50.73
February	50.66	50.60	50.42	54.55	54.57	56.38
March	52.62	52.57	52.51	59.85	59.81	68.43
April	52.62	52.57	51.33	60.12	60.08	71.96
May	52.62	52.57	50.16	60.12	60.08	70.36
June	52.62	52.57	48.06	60.12	60.08	79.28
July	50.67	50.63	46.91	60.12	60.08	91.62
August	50.62	50.61	47.46	60.12	60.08	94.74
September	50.62	50.61	48.09	60.12	60.08	87.75
October	50.62	50.61	46.57	60.12	60.08	93.61
November	50.62	50.61	45.62	60.12	60.16	102.90
December	50.62	50.61	46.34	66.56	66.37	100.93
Average	51.44	51.24	48.53	59.53	59.49	80.86

[1] Based on average monthly rates of exchange.
[2] Suspended.

Table 33.—U.S. exports of copper by class and country

Year and country	Ore, concentrates, and matte (copper content)		Ash and residues (copper content)		Refined		Scrap		Blister	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1972	r 17,662	$14,167	9,381	$5,701	182,743	$182,430	17,440	$13,397	8,569	$6,680
1973:										
Africa	1	(1)	--	--	12	16	76	113	--	--
Argentina	--	--	--	--	310	439	--	--	--	--
Belgium-Luxembourg	651	695	8,168	5,341	4,718	7,222	9,795	4,575	4,311	4,281
Brazil	2	2	23	7	21,911	33,855	253	382	--	--
Canada	3,369	3,120	289	42	12,767	17,017	8,074	8,164	1,099	1,975
Denmark	--	--	--	--	755	1,105	--	--	--	--
France	--	--	113	102	23,301	27,949	1	1	--	--
Germany, West	--	--	2,668	1,632	17,604	25,034	3,091	3,770	1,505	1,385
Guatemala	--	--	--	--	88	140	--	--	(1)	(1)
India	--	--	--	--	--	--	--	--	--	--
Italy	237	255	20	16	31,458	40,381	955	866	1	1
Japan	19,243	26,068	229	146	46,269	58,715	5,310	5,769	56	47
Korea, Republic of	--	--	17	22	4,361	6,882	6,026	7,457	--	--
Mexico	--	--	1	(1)	815	1,353	737	957	255	250
Netherlands	--	--	122	54	2,935	4,316	943	701	131	127
Oceania	--	--	--	--	95	171	--	--	--	--
Pakistan	--	--	--	--	--	--	--	--	--	--
Philippines	--	--	--	--	2,416	3,462	--	--	--	--
Spain	--	--	3,329	2,853	4	8	2,324	1,486	--	--
Sweden	--	--	13	3	1,162	1,500	142	116	--	--
Switzerland	--	--	--	--	604	727	22	31	--	--
Taiwan	--	--	--	--	5,811	8,832	1,264	925	--	--
Thailand	--	--	--	--	222	289	--	--	--	--
United Kingdom	--	--	95	78	11,669	14,430	2,870	2,906	3	2
Venezuela	--	--	--	--	12	23	--	--	--	--
Other	5	7	--	--	97	141	403	456	1	1
Total	23,508	30,147	15,087	10,296	189,396	254,007	42,286	38,675	7,362	8,069

	Pipes and tubing		Plates and sheets		Wire and cable, bare		Wire and cable, insulated		Other copper manufactures [2]	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1972	1,142	$2,461	279	$597	2,767	$4,261	28,660	$88,310	6,299	$7,400
1973:										
Africa	65	154	2	9	42	113	830	2,598	3	4
Argentina	--	--	--	--	71	112	44	223	1	1
Belgium-Luxembourg	1	4	--	--	51	84	740	1,893	70	76
Brazil	--	--	3	10	161	279	566	1,228	77	162
Canada	1,506	3,144	273	569	445	830	17,332	46,387	1,235	2,040
Denmark	--	--	--	--	14	11	52	209	--	--
France	75	172	59	114	22	50	409	1,873	19	46
Germany, West	2,691	5,484	54	97	26	68	776	2,801	4	8
Guatemala	--	--	1	3	5	12	161	212	--	--
India	--	--	--	--	2,290	2,694	21	121	--	--
Italy	31	62	3	11	13	38	369	1,212	2	4
Japan	494	1,018	1	2	5	10	564	1,704	1,332	2,863
Korea, Republic of	7	25	--	--	8	30	57	131	2	2
Mexico	1,290	2,433	8	31	566	1,016	5,884	18,210	123	157
Netherlands	177	330	1	3	35	48	204	1,059	2	3
Oceania	2	6	(1)	1	43	55	283	839	1	3
Pakistan	22	54	8	17	7	13	6	36	648	760
Philippines	35	72	4	20	6	14	327	604	101	137
Spain	162	329	1	3	18	21	62	212	--	--
Sweden	27	69	--	--	21	26	140	573	318	578
Switzerland	1	2	--	--	1	3	46	308	62	75
Taiwan	1	5	2	4	106	221	2,012	3,152	--	--
Thailand	1	6	--	--	3	4	105	235	--	--
United Kingdom	435	827	3	8	52	164	960	4,247	216	319
Venezuela	129	297	11	28	63	90	317	1,007	2,770	4,290
Other	592	1,304	40	83	1,122	1,826	7,779	17,270	445	632
Total	7,744	15,797	474	1,013	5,196	7,832	40,046	108,344	7,431	12,160

r Revised.
[1] Less than ½ unit.
[2] Does not include wire cloth: 1972—908,651 square feet ($450,713); 1973—2,017,365 square feet ($458,740).

Table 34.—U.S. exports of copper, by class

	Ore, concentrate, and matte (copper content)		Blister		Refined copper and semimanufactures	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1971	8,126	$8,430	28,698	$22,242	215,705	$267,303
1972	r 17,662	14,167	8,569	6,680	215,591	278,059
1973	23,508	30,147	7,362	8,069	242,856	386,993

	Other copper manufactures [1]		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)
1971	7,746	$9,145	260,275	$307,120
1972	6,299	7,400	r 248,121	306,306
1973	7,431	12,160	281,157	437,369

r Revised.
[1] Does not include wire cloth; 1971—1,472,504 square feet ($495,858); 1972—908,651 square feet ($450,713); 1973—2,017,365 square feet ($458,740).

Table 35.—U.S. exports of copper-base alloy (including brass and bronze), by class

Class	1972		1973	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Ingot	289	$1,074	443	$1,635
Scrap and waste	67,525	51,155	110,355	105,482
Bars, rods, and shapes	7,154	9,211	8,711	13,814
Plates, sheets, and strips	3,848	11,617	6,099	18,997
Pipes and tubing	2,035	4,060	6,854	14,356
Pipe fittings	4,073	12,297	10,036	26,820
Plumbers' brass goods	1,278	4,258	1,996	6,154
Welding rods and wire	1,254	3,238	1,792	5,228
Castings and forgings	909	1,491	701	1,369
Powder and flakes	1,850	2,967	2,487	4,954
Foil	162	488	414	1,113
Articles of copper and copper-base alloys, n.e.c	(1)	3,730	(1)	5,327
Total	90,377	105,586	149,888	205,249

[1] Quantity not reported.

Table 36.—U.S. exports of unfabricated copper-base alloy [1] ingots, bars, rods, shapes, plates, sheets, and strip

Year	Short tons	Value (thousands)
1971	8,727	$16,282
1972	11,291	21,902
1973	15,253	34,446

[1] Includes brass and bronze.

Table 37.—U.S. exports of copper sulfate (blue vitriol)

Year	Short tons	Value (thousands)
1971	2,815	$2,078
1972	2,646	1,767
1973	1,716	2,043

Table 38.—U.S. exports of copper scrap, by country

Country	Unalloyed copper scrap				Copper alloy scrap			
	1972		1973		1972		1973	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Belgium-Luxembourg	940	$775	9,795	$4,575	1,089	$755	8,079	$7,602
Brazil	--	--	253	382	--	--	1,282	1,489
Canada	4,177	2,955	8,074	8,164	5,953	5,160	10,564	10,641
El Salvador	--	--	--	--	--	--	170	77
France	--	--	1	1	47	38	113	129
Germany:								
East	161	144	155	164	66	42	--	--
West	495	430	3,091	3,770	2,993	2,382	10,436	10,741
Hong Kong	--	--	20	26	59	50	146	156
India	20	20	--	--	229	224	--	--
Israel	--	--	20	23	--	--	428	423
Italy	950	692	955	866	8,254	5,433	8,490	7,255
Japan	4,804	4,007	5,310	5,769	40,928	31,008	44,947	43,585
Korea, Republic of	1,726	1,505	6,026	7,457	3,583	3,163	9,542	10,544
Mexico	2,040	1,257	737	957	138	113	238	209
Netherlands	--	--	943	701	371	304	1,394	1,450
Pakistan	--	--	--	--	3	2	350	274
Spain	1,579	1,099	2,324	1,486	1,894	1,109	1,585	1,308
Sweden	--	--	142	116	1,078	715	1,310	882
Taiwan	139	134	1,264	925	132	112	3,649	1,862
United Kingdom	129	141	2,870	2,906	558	397	7,229	6,599
Venezuela	1	(1)	--	--	--	--	153	45
Yugoslavia	--	--	183	221	--	--	--	--
Other	279	238	123	166	150	148	250	211
Total	17,440	13,397	42,286	38,675	67,525	51,155	110,355	105,482

[1] Less than ½ unit.

Table 39.—U.S. imports for consumption of copper scrap, by country

Country	Unalloyed copper scrap (copper content)			
	1972		1973	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Bahamas	39	$29	41	$33
Belgium-Luxembourg	--	--	192	357
Bermuda	19	17	--	--
Canada	7,831	7,393	11,280	15,042
Chile	254	220	--	--
Dominican Republic	73	54	316	345
France	105	146	136	222
Germany, West	56	42	203	314
Guatemala	93	91	149	126
Honduras	42	55	107	94
Jamaica	76	51	141	123
Japan	322	68	156	46
Mexico	1,445	1,143	4,609	3,839
Netherlands	5	6	88	158
Netherlands Antilles	2	1	19	21
Nicaragua	72	59	93	100
Panama	189	157	82	85
Switzerland	--	--	84	70
Trinidad and Tobago	--	--	45	50
United Kingdom	155	219	513	927
Other	9	15	12	15
Total	10,787	9,766	18,266	21,967

Table 39.—U.S. imports for consumption of copper scrap, by country—Continued

Country	Copper alloy scrap					
	1972			1973		
	Quantity			Quantity		
	Gross weight short tons	Content short tons	Value (thousands)	Gross weight short tons	Content short tons	Value (thousands)
Bahamas	73	46	$46	114	76	$69
Belgium-Luxembourg	--	--	--	45	26	51
Canada	10,020	6,524	6,820	10,154	6,623	9,874
Dominican Republic	609	510	396	295	249	222
Finland	--	--	--	80	58	95
France	13	11	11	--	--	--
Germany, West	21	14	9	152	95	167
Gibraltar	10	7	7	--	--	--
Guatemala	85	69	66	140	107	65
Haiti	28	22	19	--	--	--
Hong Kong	--	--	--	229	200	244
Israel	34	30	27	--	--	--
Jamaica	29	28	21	9	8	6
Japan	17	12	10	69	43	61
Mexico	257	142	129	436	340	366
Netherlands	--	--	--	88	71	127
Netherlands Antilles	2	1	(1)	18	15	19
Nicaragua	25	18	15	37	33	46
Panama	213	163	141	69	52	47
Spain	20	16	14	1	(1)	(1)
Switzerland	--	--	--	58	33	67
Trinidad and Tobago	111	88	64	119	83	84
United Kingdom	318	267	269	20	17	17
Other	1	(1)	1	--	--	--
Total	11,886	7,968	8,065	12,133	8,129	11,627

[1] Less than ½ unit.

Table 40.—U.S. imports[1] of copper (unmanufactured), by class and country

(Short tons, copper content, and thousand dollars)

Year and country	Ore, concentrates		Matte		Blister	
	Quantity	Value	Quantity	Value	Quantity	Value
1971	30,848	27,502	440	460	156,744	147,128
1972:						
Australia	2,091	1,607	--	--	44	45
Canada	11,603	8,628	515	355	5,871	5,598
Chile	--	--	71	36	33,208	31,197
Colombia	55	4	--	--	--	--
Finland	--	--	11	11	--	--
Germany, West	--	--	--	--	1	(2)
India	--	--	--	--	110	108
Israel	--	--	--	--	14	12
Japan	--	--	--	--	18	26
Kenya	--	--	--	--	1,804	1,653
Mexico	8	2	--	--	9,544	9,868
Nicaragua	95	64	--	--	--	--
Panama	195	125	--	--	--	--
Peru	9,486	8,929	--	--	81,559	71,806
Philippines	30,122	29,677	--	--	--	--
South Africa, Republic of	--	--	--	--	23,053	22,360
United Kingdom	--	--	761	685	1	3
Yugoslavia	--	--	--	--	2,205	2,088
Total	53,655	49,036	1,358	1,087	157,432	144,764
1973:						
Australia	1,531	1,466	--	--	--	--
Canada	11,291	9,419	292	123	1,181	1,236
Chile	1,654	555	--	--	29,617	34,619
Colombia	7	3	--	--	--	--
Germany, West	--	--	--	--	2	4
Italy	28	10	--	--	--	--
Japan	--	--	--	--	11	16
Mexico	682	236	431	393	8,799	11,046
Nicaragua	200	226	--	--	--	--
Peru	8,697	13,846	--	--	86,896	123,011

See footnotes at end of table.

Table 40.—U.S. imports[1] of copper (unmanufactured), by class and country—Continued

(Short tons, copper content, and thousand dollars)

Year and country	Ore, concentrates		Matte		Blister	
	Quantity	Value	Quantity	Value	Quantity	Value
1973—Continued						
Philippines	17,842	27,360	--	--	--	--
South Africa, Republic of	--	--	--	--	26,279	27,569
Uganda	--	--	--	--	110	98
U.S.S.R	--	--	--	--	272	273
United Kingdom	--	--	23	26	(2)	1
Venezuela	203	160	--	--	--	--
Yugoslavia	--	--	--	--	937	917
Total	42,135	53,281	746	542	154,104	198,790

Year and country	Refined		Scrap		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1971	163,988	165,300	7,459	6,679	359,479	347,069
1972:						
Australia	388	394	--	--	2,523	2,046
Brazil	370	377	--	--	370	377
Canada	124,983	123,494	7,831	7,393	150,803	145,468
Chile	26,598	25,520	254	220	60,131	56,973
Colombia	--	--	--	--	55	4
Finland	--	--	--	--	11	11
France	8	8	105	146	113	154
Germany, West	1	3	56	42	58	45
Honduras	--	--	42	55	42	55
India	--	--	--	--	110	108
Israel	--	--	--	--	14	12
Japan	1,125	1,045	322	68	1,465	1,139
Kenya	--	--	--	--	1,804	1,653
Mexico	7,620	7,568	1,445	1,143	18,617	18,581
Nicaragua	--	--	72	59	167	123
Norway	208	201	--	--	208	201
Panama	--	--	189	157	384	282
Peru	2,204	2,047	--	--	93,249	82,782
Philippines	--	--	--	--	30,122	29,677
South Africa, Republic of	556	519	--	--	23,609	22,879
United Kingdom	3,938	4,172	155	219	4,855	5,079
Yugoslavia	24,379	23,534	--	--	26,584	25,622
Other	1	1	316	264	317	265
Total	192,379	188,883	10,787	9,766	415,611	393,536
1973:						
Australia	498	1,071	--	--	2,029	2,537
Belgium-Luxembourg	9,458	16,653	192	357	9,650	17,010
Canada	130,523	157,486	11,892	15,933	155,179	184,197
Chile	27,492	38,703	--	--	58,763	73,877
Colombia	--	--	--	--	7	3
France	805	1,388	136	222	941	1,610
Germany, West	8,627	15,878	203	314	8,832	16,196
Italy	--	--	--	--	28	10
Japan	22	20	156	46	189	82
Mexico	2,132	2,608	4,667	3,916	16,711	18,199
Netherlands	1,585	2,331	88	158	1,673	2,489
Nicaragua	--	--	93	100	293	326
Norway	306	365	--	--	306	365
Peru	4,384	4,959	--	--	99,977	141,816
Philippines	--	--	--	--	17,842	27,360
Poland	689	1,140	--	--	689	1,140
South Africa, Republic of	81	74	--	--	26,360	27,643
Sweden	339	583	--	--	339	583
Tanzania	901	1,621	--	--	901	1,621
Uganda	--	--	--	--	110	98
U.S.S.R	--	--	--	--	272	273
United Kingdom	7,698	9,169	513	927	8,234	10,123
Venezuela	--	--	--	--	203	160
Yugoslavia	381	394	--	--	1,318	1,311
Zambia	5,455	5,279	--	--	5,455	5,279
Other	137	146	996	962	1,133	1,108
Total	201,513	259,868	18,936	22,935	417,434	535,416

[1] Data are general imports, that is, they include copper imported for immediate consumption plus material entering the country under bond.
[2] Less than ½ unit.

Table 41.—U.S. imports for consumption of copper (copper content) by class

Year	Ore and concentrates		Matte		Blister	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1971	5,547	$4,091	119	$220	153,625	$144,395
1972	80,740	81,055	1,453	1,134	77,162	72,514
1973	19,582	16,029	139	106	128,166	159,922

Year	Refined		Scrap		Total value (thousands)
	Short tons	Value (thousands)	Short tons	Value (thousands)	
1971	163,988	$165,300	7,459	$6,679	$320,685
1972	175,703	172,772	10,787	9,766	337,241
1973	206,297	262,706	18,266	21,967	460,730

Table 42.—Copper: World mine production by country [1]

(Short tons)

Country	1971	1972	1973 [p]
North and Central America:			
Canada [2]	721,429	793,303	899,475
Cuba [e]	3,300	3,300	5,500
Dominican Republic [e]	500	500	500
Haiti [3]	7,300	(4)	--
Mexico	69,611	86,774	88,737
Nicaragua [3]	4,037	2,412	1,703
United States [2]	1,522,183	1,664,840	1,717,940
South America:			
Argentina	[r] 557	1,250	[e] 1,300
Bolivia [5]	8,281	9,324	[e] 9,500
Brazil	[6] 5,622	4,745	6,711
Chile	790,722	799,968	818,804
Colombia	62	71	[e] 80
Ecuador	622	483	530
Peru	[r] 228,560	248,031	241,156
Europe:			
Albania [7]	6,504	[r] [e] 6,970	[e] 7,100
Austria	2,920	2,539	3,023
Bulgaria	[r] 38,600	41,900	[e] 44,100
Czechoslovakia	[r] 5,180	5,180	6,600
Finland	31,317	32,121	41,192
France	[r] 368	520	456
Germany, East [e]	[r] 5,500	[r] 3,300	1,700
Germany, West [8]	[r] 1,636	1,456	1,583
Greece	1,577	1,715	1,587
Hungary [e]	1,300	1,300	1,400
Ireland	[r] 13,104	14,560	14,336
Italy [8]	1,698	1,156	1,000
Norway [8]	23,889	27,971	31,320
Poland	134,700	148,800	170,900
Portugal [8]	4,362	6,744	6,409
Romania [e] [2]	15,700	38,600	46,300
Spain [8] [9]	37,514	39,812	33,370
Sweden	33,313	33,752	35,712
U.S.S.R. [e] [2] [7]	680,000	733,000	772,000
Yugoslavia	104,049	113,685	162,857
Africa:			
Algeria	567	472	441
Congo (Brazzaville) [3]	[r] 1,816	1,511	[e] 1,500
Kenya	80	79	[e] 70
Mauritania	4,960	16,342	23,454
Morocco [3]	[r] 4,234	4,220	4,762
Mozambique [3]	456	198	265
Rhodesia, Southern [10]	32,338	42,218	46,100
South Africa, Republic of	173,581	178,494	193,783
South-West Africa, Territory of [3] [11]	35,317	23,830	30,282
Uganda	[r] 17,906	17,346	17,286
Zaire	447,349	472,008	538,312
Zambia	[r] 718,040	791,128	778,864

See footnotes at end of table.

Table 42.—Copper: World mine production by country[1]—Continued

(Short tons)

Country	1971	1972	1973 p
Asia:			
Burma[12]	88	88	77
China, People's Republic of e	110,000	110,000	110,000
Cyprus[8]	r 21,491	20,884	16,799
India	11,867	12,856	16,085
Indonesia	--	5,500	41,800
Iran[13]	1,106	1,323	3,300
Israel	11,161	12,318	11,202
Japan[14]	133,411	123,584	100,619
Korea, North e	14,000	14,000	14,000
Korea, Republic of	1,955	2,295	2,558
Malaysia e	r 230	65	55
Philippines	217,787	235,558	243,825
Taiwan e	r 2,650	r 2,760	2,650
Turkey	24,736	27,514	e 41,300
Oceania:			
Australia	r 195,397	205,925	240,800
Fiji	--	3	--
New Zealand	94	136	e 110
Papua New Guinea	--	136,641	201,502
Total	r 6,688,634	7,329,378	7,856,682

e Estimate. p Preliminary. r Revised.

1 Data presented represent copper content (recoverable where indicated) of ore mined wherever possible. If such data are not available, the nonduplicative total copper content of ores, concentrates, matte, metal and/or other copper-bearing products measured at the least stage of processing for which data are available has been used.

2 Recoverable.

3 Copper content of concentrate produced.

4 Revised to zero.

5 Corporación Minera de Bolivia (COMIBOL) production plus exports by medium and small mines.

6 Partly estimated, partly calculated on the basis of data furnished by Companhia Brasileira de Cobre.

7 Smelter production.

8 Includes copper content of cupriferous pyrites.

9 Excludes an unreported quantity of copper in iron pyrites which may or may not be recovered.

10 Year ending September 30 of that stated.

11 Data are compiled from operating company reports of Tsumeb Corp. Ltd. and General Mining and Finance Corp. Ltd. for Klein Aub Loper Maatskappy Ltd.'s mine near Rehoboth. Data for 1971 are for fiscal year ending June 30, 1971; data for 1972 are a summation of company figures for calendar year 1972 for Tsumeb Corp. Ltd. and for fiscal year ending June 30, 1972, for General Mining and Finance Corp.; data for 1973 are a summation of company figures for calendar year 1973 for Tsumeb Corp. Ltd. and for fiscal year ending June 30, 1973, for General Mining and Finance Corp. Output of Tsumeb Corp. Ltd. for the period July 1, 1971, through December 31, 1971, was 12,813 short tons.

12 Copper content of matte produced.

13 Year beginning March 21 of that stated.

14 Copper content of concentrate. Copper content of run of mine production was as follows in short tons: 1971—133,411; 1972—125,248; 1973—103,871.

Table 43.—Copper: World smelter production by country [1]

(Short tons)

Country	1971	1972	1973 p
North America:			
Canada	r 509,598	522,200	545,641
Mexico [2]	68,273	81,831	77,713
United States [3]	1,499,996	1,690,391	1,743,963
South America:			
Argentina e	r 44	90	90
Brazil	4 5,620	5,290	4,630
Chile [5]	704,462	725,437	700,501
Peru	r 147,480	148,316	152,192
Europe:			
Albania	r 6,504	e 6,970	e 7,100
Austria [6]	1,653	1,433	330
Belgium [7]	19,800	14,300	17,600
Bulgaria	50,000	53,000	58,000
Czechoslovakia	5,000	6,600	6,600
Finland	r 30,924	38,751	45,836
Germany, East e	2,200	2,650	1,650
Germany, West	r 91,102	175,738	264,122
Hungary e	1,300	1,300	1,300
Norway [8]	37,988	37,372	36,690
Poland [9]	102,200	144,403	172,401
Portugal	r 4,960	4,189	4,409
Romania e	12,000	38,600	46,300
Spain	73,047	88,317	104,082
Sweden [6]	41,268	40,836	48,875
U.S.S.R. e	680,000	733,000	772,000
Yugoslavia	122,692	164,296	174,628
Africa:			
Rhodesia, Southern [10]	30,764	45,277	e 46,000
South Africa, Republic of	r 167,882	184,968	165,347
South-West Africa, Territory of [11]	29,676	28,791	39,737
Uganda	17,340	15,618	10,684
Zaire	r 445,995	472,009	507,591
Zambia	r 709,528	768,629	759,024
Asia:			
China, People's Republic of e	110,000	110,000	110,000
India	10,668	11,538	12,070
Iran [12] [13]	3,249	4,480	e 5,000
Japan	r 646,836	765,885	960,332
Korea, North e	14,000	14,000	14,000
Korea, Republic of	r 7,562	11,354	e 11,500
Taiwan [12]	r 4,080	3,860	3,970
Turkey	18,566	18,433	27,242
Oceania: Australia	r 157,484	159,455	178,816
Total	r 6,591,741	7,339,607	7,837,966

e Estimate. p Preliminary. r Revised.

[1] Unless otherwise noted, data presented for each country represent primary copper metal output, whether produced by thermal or electrowinning. To the extent possible, refined copper produced from imported blister or electrolytic anode copper has been excluded.

[2] Copper content of impure bars and electrolytic copper.

[3] Smelter output of domestic and foreign ores, exclusive of that produced from scrap. Production from domestic ores only was as follows: 1971—1,470,815; 1972—1,649,130; and 1973—1,705,065.

[4] Includes secondary copper (production from scrap). Partly estimated, partly calculated on the basis of data furnished by Companhia Brasileira de Cobre.

[5] Data are the nonduplicative sum of: (1) the copper content of blister copper production for sale as such; (2) the copper content of blister produced for refining in Chile at the Ventanas refinery; and (3) the copper content of fire refined and electrolytic copper (including copper obtained by electrowinning) excluding electrolytic output of the Ventanas refinery.

[6] Series revised from refined to smelter basis.

[7] Belgium reports a large output of refined copper, but this is produced largely from imported blister; domestic smelter production is reported output of blister copper from ores.

[8] Reported Norwegian copper output is derived in part from copper-nickel matte imported from Canada, and reported Canadian smelter production may also include this material. Norwegian smelter output from domestic ores was as follows (approximately) in tons: 1971—6,700; 1972—7,500; and 1973—7,500.

[9] Refined output.

[10] Year ending September 30 of that stated.

[11] Year ending June 30 of that stated.

[12] Includes secondary.

[13] Year beginning March 21 of that stated.

Table 44.—Copper: World refinery production by country[1]

(Short tons)

Country	1971	1972	1973 p
North America:			
Canada [2]	526,403	546,685	548,489
Mexico	57,956	65,688	68,233
United States	1,591,782	1,873,233	1,868,488
South America:			
Argentina e	44	90	90
Brazil [2]	25,463	29,542	32,187
Chile [3]	497,825	563,239	525,544
Peru	35,892	43,225	42,964
Europe:			
Albania e	6,500	7,000	7,100
Austria	23,474	25,015	25,215
Belgium [4]	359,205	360,762	e 380,000
Bulgaria	45,195	49,604	52,911
Czechoslovakia [2]	18,955	19,917	22,046
Finland	35,647	42,355	47,297
France	16,535	17,196	e 17,200
Germany, East e	44,000	44,000	44,000
Germany, West [2]	440,981	439,297	448,263
Hungary e [2]	13,000	19,000	19,000
Norway	30,555	29,155	28,446
Poland	102,184	144,403	172,401
Portugal	4,630	1,990	2,406
Romania e	12,000	38,600	46,300
Spain	122,050	150,254	135,473
Sweden	38,076	45,706	e 47,400
U.S.S.R. e	650,000	697,000	733,000
United Kingdom	54,582	65,674	83,619
Yugoslavia	99,760	141,769	147,334
Africa:			
Rhodesia, Southern [5]	25,683	33,069	33,069
South Africa, Republic of	87,303	87,413	99,869
Zaire [6]	229,106	238,430	246,429
Zambia	589,007	678,165	703,835
Asia:			
China, People's Republic of e	110,000	120,000	130,000
India	10,582	11,574	9,590
Iran	1,100	1,100	1,300
Japan	786,295	892,821	1,048,057
Korea, North e	14,000	14,000	14,000
Korea, Republic of [2]	7,550	9,988	10,192
Taiwan	[2] 4,045	[2] 5,156	1,743
Turkey	19,312	16,535	16,402
Oceania: Australia	140,042	153,339	159,299
Total	6,876,719	7,721,989	8,019,191

e Estimate. p Preliminary.
[1] Unless otherwise noted, data presented for each country represent total primary refined copper (both fire refined and electrolytically refined), including material refined from imported crude copper (blister and electrolytic anode).
[2] Includes secondary.
[3] Includes electrolytic output of the Ventanas refinery.
[4] Data include leach cathodes from Zaire, secondary, and alloy material.
[5] Year ending September 30 of that stated.
[6] Excludes metal content of leach cathodes which are included in Belgium production.

Table 45.—Chile: Exports of copper, by type

(Short tons)

Destination	1972 r: Ore and concentrate	1972 r: Blister	1972 r: Refined: Electrolytic	1972 r: Refined: Fire refined	1972 r: Refined: Total	1973: Ore and concentrate	1973: Blister	1973: Refined: Electrolytic	1973: Refined: Fire refined	1973: Refined: Total
Argentina	--	--	26,100	5,000	31,100	--	--	28,200	7,400	35,600
Belgium	1,300	3,900	1,700	3,500	10,400	200	5,100	200	5,200	10,700
Brazil	--	--	7,200	1,500	8,700	--	--	10,800	2,500	13,300
Canada	--	--	--	--	--	11,100	--	--	--	11,100
China, People's Republic of	--	33,400	16,500	--	49,900	--	39,100	22,000	--	61,100
France	--	--	17,500	17,800	35,300	3,000	--	17,000	5,300	25,300
Germany, West	18,300	34,100	80,400	20,300	153,100	16,800	28,200	65,500	20,800	131,300
Greece	7,900	11,800	--	--	19,700	3,900	26,000	--	--	29,900
Italy	--	800	43,100	16,100	60,000	--	--	40,800	10,000	50,800
Japan	40,900	15,500	34,100	--	90,500	64,900	14,300	23,500	--	102,700
Netherlands	--	--	4,000	1,100	5,100	2,000	--	--	--	2,000
Spain	9,200	--	4,300	700	14,200	5,400	2,200	4,900	2,000	14,500
Sweden	800	3,600	13,400	5,400	23,200	--	--	19,400	--	19,400
Switzerland	--	--	1,700	1,000	2,700	--	--	900	--	900
U.S.S.R	--	--	7,100	1,800	8,900	8,900	--	6,600	--	15,500
United Kingdom	--	34,500	44,100	12,400	91,000	1,600	26,900	46,800	17,500	92,800
United States	200	27,400	35,100	11,500	74,200	600	17,900	42,400	3,900	64,800
Other	4,000	--	13,100	300	17,400	2,100	16,000	23,600	300	42,000
Total	82,600	165,000	349,400	98,400	695,400	120,500	175,700	352,600	74,900	723,700

r Revised.

Source: Corporación del Cobre Chile. Indicadores del Cobre y Sub-Productos.

Table 46.—Canada: Copper production (all sources) by Province[1]

(Short tons)

Province	1972 r	1973 p
British Columbia	233,506	354,271
Manitoba	59,831	74,121
New Brunswick	10,311	9,823
Newfoundland	9,513	6,616
Northwest Territories	567	835
Nova Scotia	--	15
Ontario	289,723	277,261
Quebec	176,432	155,345
Saskatchewan	12,546	10,395
Yukon Territory	874	10,793
Total	793,303	899,475

p Preliminary. r Revised.

[1] Blister copper plus recoverable copper in matte and concentrate exported.

Source: Dominion Bureau of Statistics, Department of Trade and Commerce, Canada. Canada's Mineral Production, Preliminary Estimate. 1973.

Diatomite

By Benjamin Petkof [1]

Domestic diatomite production remained strong in 1973, increasing 6% in quantity compared with 1972 data; value declined 4%. The United States retained its position as a major world producer of processed diatomite. U.S. exports of processed diatomite to nations throughout the world increased in both quantity and value over those of 1972.

[1] Physical scientist, Division of Nonmetallic Minerals—Mineral Supply.

DOMESTIC PRODUCTION

All U.S. production was derived from open pit operations in the western States of California, Nevada, Washington, and Oregon. California remained the largest producing State. Arizona reported no production for the year.

During 1973, 8 companies, with a total of 10 operations, actively mined and prepared diatomite to supply the demand of various industrial end users. The following companies supplied the bulk of the processed diatomite production: Johns-Manville Products Corp., with a quarry and processing plant near Lompoc, Calif.; Grefco, Inc., with operations near Lompoc, Calif., and Mina, Nev.; Eagle-Picher Industries, Inc., with facilities near Sparks and Lovelock, Nev.; and Kenite Corp., Division of Whitco Chemical Corp., with an operation near Quincy, Wash. The remaining producers were Basalt Rock Co. Inc., near Napa, Calif.; Airox, Inc., near Santa Maria, Calif.; Fernley Division, Cyprus Mines Corp., near Fernley, Nev.; and A. M. Matlock, near Christmas Valley, Oreg.

Table 1.—Diatomite sold or used by producers in the United States

	1969	1970	1971	1972	1973
Domestic production (sales) short tons	598,482	597,636	535,318	576,089	608,906
Average value per ton	$60.96	$54.63	$64.25	$65.19	$59.26

CONSUMPTION AND USES

All major end uses reported significant gains in consumption. However, the quantities consumed for abrasives and industrial fillers declined. Filtration remained the major end use of diatomite and required slightly in excess of three-fifths of domestic demand. Abrasives, industrial fillers and lightweight aggregates accounted for almost one-fourth of demand. The remainder was consumed for miscellaneous end uses such as a pozzolan, soil conditioner, inert carrier, and coating agent.

Table 2.—Domestic consumption of diatomite, by principal use

(Percent of total consumption)

Use	1969	1970	1971	1972	1973
Filtration	58	58	59	58	61
Fillers	20	19	W	W	W
Insulation	4	4	3	4	4
Miscellaneous	18	19	38	38	35

W Withheld to avoid disclosing individual company confidential data; included with "Miscellaneous."

PRICES

The weighted average value per ton of diatomite, for all end uses in 1973, declined 9% from that of 1972. This decline was caused by price decreases for major end uses such as filtration, industrial fillers, and miscellaneous uses. Uses such as insulation and lightweight aggregate showed price increases. The price of abrasive material varied only slightly.

Table 3.—Average annual value per ton of diatomite, by use

Use	1972	1973
Filtration	$73.08	$65.18
Insulation	47.02	50.39
Abrasives	125.27	125.46
Fillers	69.37	62.01
Lightweight aggregate	43.07	45.02
Miscellaneous	39.01	36.99
Weighted average	65.19	59.26

FOREIGN TRADE

Exports of prepared diatomite increased 20% in quantity and 15% in value over those of 1972. Exports represented 29% of domestic production. Major countries of destination were Canada 27%, Japan 10%, Federal Republic of Germany 8%, the United Kingdom 8%, Australia 5%, Brazil 4%, Republic of South Africa 4%, Italy 3%, and Spain 3%. The remainder was shipped to many other developed and less-developed countries of the world for various end uses. The average value of exported material was $81.64 per ton. Imports of diatomite totaled 164 tons, valued at $23,635. The bulk of the imports were received from Mexico; the remainder, from the United Kingdom.

Table 4.—U.S. exports of diatomite

(Thousand short tons and thousand dollars)

Year	Quantity	Value
1971	142	11,752
1972	148	12,603
1973	178	14,532

WORLD REVIEW

Overall world diatomite production, which varied only slightly from that of 1972, continued to meet the strong demand of the consuming nations.

Kenya.—Diatomite is a small but significant fraction of the mineral output of the country. Large diatomite deposits are found in the area of the Rift Valley. African Diatomite Industries, Ltd., a subsidiary of the Government of Kenya's Industrial and Commercial Development Corp., mines diatomite from the Kariandusi deposit near Gilgil. This operation provides all of the country's diatomite output, which is marketed by the Johns-Manville Products Corp. for use as filter aid, insulation, and industrial filler.

Table 5.—Diatomite: World production by country

	1971	1972	1973 p
North America:			
Canada e	500	500	NA
Costa Rica	23,149	e 23,000	e 23,000
Mexico	r 24,033	10,006	e 17,000
United States	535,318	576,089	608,906
South America:			
Argentina	10,568	e 10,600	e 10,600
Colombia	331	394	386
Peru	4,162	r e 4,400	e 4,400
Europe:			
Austria	3,400	2,704	e 2,800
Denmark:			
Diatomite e	22,000	22,000	22,000
Moler e	240,000	240,000	240,000
Finland	(1)	(1)	--
France	185,703	e 190,000	e 190,000
Germany, West (marketable)	97,787	63,985	e 50,700
Iceland	e 20,995	24,251	e 24,250
Italy e	65,000	65,000	65,000
Portugal	r 5,149	1,820	e 2,200
Spain	20,211	e 22,000	e 22,000
Sweden	5,585	(1)	--
U.S.S.R. e	410,000	420,000	430,000
United Kingdom	16,049	9,900	e 11,000
Africa:			
Egypt, Arab Republic of (diatomite clay)	2,480	1,839	e 1,900
Kenya	1,543	1,997	137
South Africa, Republic of	358	346	e 680
Asia: Korea, Republic of	3,486	2,155	4,389
Oceania:			
Australia	r 2,124	1,616	e 1,650
New Zealand	6,986	5,507	e 5,500
Total	r 1,706,917	1,700,109	1,738,498

e Estimate. p Preliminary. r Revised. NA Not available.
[1] Revised to zero.

TECHNOLOGY

A recent Government publication reviewed the resource position of diatomite and concluded that domestic and other world diatomite resources are adequate for the foreseeable future. It was also indicated that the requirement for diatomite near markets and for particular uses encouraged the development of new sources. The paper also proposed that studies relating the geologic setting and history of diatomite to the occurrence and properties of the host rock would assist in the location of undiscovered deposits.[2]

[2] Durham, D. L. United States Mineral Resources. U.S. Geol. Survey Prof. Paper 820, 1973, pp. 191–195.

Feldspar, Nepheline Syenite, and Aplite

By J. Robert Wells [1]

Domestic production of crude feldspar, after several years of indecisive ups and downs, rose sharply in 1973 and exceeded the corresponding figure for the preceding year by 8% and that for 1969, the record year heretofore, by 5%. Coinciding imports of more Canadian nepheline syenite than ever before, supplemented by near-record production of domestic aplite, attested that 1973 domestic consumption of feldspathic materials was at the highest level in history.

The feldspar industry was faced in 1973 with a number of unaccustomed problems, some already full-grown and some only recently emerging. It was evident in 1972 that new legislative programs relating to air, water, and noise pollution, land-use restrictions, and mined-land rehabilitation were becoming major incremental factors in determining feldspar production costs. Price increases passed on to purchasers early in 1973 were a predictable consequence, and in a related development, land-use and/or environmental impediments were reported to have been decisive in the September 1973 termination of Del Monte Properties' long-established feldspar operations in California. Many major producers depend heavily upon heat from natural gas for the drying of flotation cake feldspar and also use substantial quantities of fuel oil both for that purpose and as a necessary reagent in the flotation process. Potential deficits in the supply of those hydrocarbons looming toward yearend 1973 gave rise to deep concern and uncertainty that carried over into 1974. Indirect consequences from such shortages—possible curtailment of the production of energy-intensive (and feldspar consuming) glass and ceramics—could be foreseen as further unsettling influences in the industry's future.

Legislation and Government Programs.—According to provisions of the Tax Re-

[1] Physical scientist, Division of Nonmetallic Minerals—Mineral Supply.

Table 1.—Salient feldspar statistics

	1969	1970	1971	1972	1973
United States:					
Crude:					
Sold or used by producers____short tons__	754,863	726,069	742,810	732,439	791,900
Value__________________thousands__	$8,869	$9,638	$9,969	$10,372	$12,830
Average value per short ton_________	$11.75	$13.27	$13.42	$14.16	$16.20
Imports for consumption_____short tons__	52	252	134	187	264
Value__________________thousands__	$7	$23	$19	$23	$22
Average value per short ton_________	$134.62	$91.27	$141.79	$123.00	$83.33
Consumption, apparent [1]______short tons__	754,915	726,321	742,944	732,626	792,164
Ground:					
Sold by merchant mills_______short tons__	793,052	647,995	601,618	580,801	588,698
Value__________________thousands__	$10,465	$9,458	$8,716	$8,990	$10,628
Average value per short ton_________	$13.20	$14.60	r $14.49	$15.48	$18.05
Exports____________________short tons__	6,325	5,570	3,984	5,275	9,554
Value__________________thousands__	$358	$195	$141	$184	$466
Average value per short ton_________	$56.60	$35.01	$35.39	$34.88	$48.78
Imports for consumption_____short tons__	5,201	3,637	2,375	945	103
Value__________________thousands__	$128	$93	$65	$20	$4
Average value per short ton_________	$24.61	$25.57	$27.38	r $21.16	$38.83
World production___________thousand short tons__	2,697	2,786	r 2,815	r 2,805	2,794

r Revised.
[1] Measured by quantity sold or used by producers plus imports.

form Act of 1969, which continued in force throughout 1973, the depletion rate allowed on feldspar production (both domestic and foreign operations) was 14%.

FELDSPAR

DOMESTIC PRODUCTION

Crude Feldspar.—In 1973, crude feldspar was mined in eight States (one fewer than in 1972), with North Carolina the leader in tonnage, followed in descending order by California, Connecticut, Georgia, South Dakota, Arizona, Wyoming, and Colorado. The combined outputs of the first four States named amounted to almost 94% of the U.S. total. South Carolina, after 14 years of inclusion in the list of feldspar-producing States, dropped out when Spartan Minerals Co. discontinued extraction of that mineral from fines generated in the crushing of Spartanburg County granite, switching instead to treatment of ore shipped from Bessemer City, N.C.

Table 2.—Crude feldspar sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Hand-cobbed		Flotation concentrate		Feldspar-silica mixtures [1]		Total [2]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1969	68	494	371	4,912	316	3,462	755	8,869
1970	53	543	415	5,395	258	3,699	726	9,638
1971	45	749	443	5,454	255	3,766	743	9,969
1972	25	392	535	7,354	172	2,627	732	10,372
1973	53	636	546	9,789	193	2,406	792	12,830

[1] Feldspar content.
[2] Data may not add to totals shown because of independent rounding.

Ground Feldspar.—Most of the feldspar used in glassmaking is ground no finer than 20 mesh, but feldspar to be used in ceramics and filler applications is usually pulverized to minus 200 mesh or finer. Nine companies, operating 14 plants in 8 States, ground feldspar for market in 1973, supplying ground material (total tonnage 1% more than in 1972) for shipment to destinations in at least 24 States, Puerto Rico, Canada, and Mexico. Listed in descending order of output tonnages, North Carolina had six grinding mills, while Connecticut, Georgia, and South Carolina had one each. These were the leaders in ground feldspar production and jointly accounted for 90% of the 1973 total. South Dakota with two mills, followed by California, Arizona, and Wyoming with one each, were the four States making up the remaining 10%. Colorado was the only crude feldspar-producing State in 1973 in which no grinding mill was operated.

CONSUMPTION AND USES

Crude Feldspar.—In 1973 there was no significant consumption of feldspar in the raw, unprocessed state in which it is taken from the mine; the majority of users acquired their supplies already ground and sized either by the primary producers or by merchant grinders. Some manufacturers of pottery, soaps, and enamels, however, continued their customary practice of purchasing crude feldspar for grinding to their preferred specifications in their own mills. The Bureau of Mines canvass of producers and merchant grinders does not provide information concerning the end-use distribution of the material handled in this way.

Ground Feldspar.—The 1973 pattern of ground feldspar consumption in the United States was not strikingly different from that of the preceding year, but the confidential status of some of the data precludes a detailed comparison. The 1973 end-use distribution showed that 53% of the total was consumed for glassmaking and 47% went for pottery, enamel, and miscellaneous uses compared with 1972 data showing 50% for glass, 44% for pottery, and 6% for enamel and other uses.

Table 3.—Production of ground feldspar, by use

(Short tons and thousand dollars)

Use	1972 Quantity	1972 Value	1973 Quantity	1973 Value
Hand-cobbed:				
Glass	1,800	$45	--	--
Pottery	12,186	263	36,860	$1,000
Enamel	8,371	165	W	W
Soap	2,627	55	240	7
Other	168	4	17,018	495
Total	25,152	532	54,118	1,502
Flotation concentrate:				
Glass	256,584	3,034	217,267	3,302
Pottery	196,443	3,631	115,569	2,616
Other	5,614	127	11,512	249
Total	458,641	6,792	344,348	6,167
Feldspar-silica mixture: [1]				
Glass	29,352	347	91,897	1,179
Pottery	49,284	778	75,698	1,309
Other	18,372	543	22,637	471
Total	97,008	1,668	190,232	2,959
Total:				
Glass	287,736	3,426	309,164	4,481
Pottery	257,913	4,672	228,127	4,925
Enamel	8,371	165	W	W
Soap	2,627	55	240	7
Other [2]	24,154	674	51,167	1,215
Total	580,801	[3] 8,990	588,698	10,628

W Withheld to avoid disclosing individual company confidential data; included with "Other."
[1] Feldspar content.
[2] Includes plastics, refractories, rubber, and data indicated by symbol W.
[3] Data does not add to total shown because of independent rounding.

STOCKS

From a comparison of 1973 data on domestic production and sales of feldspar, it was estimated that U.S. producers had 283,000 short tons of feldspar (crude, ground, or in process) on hand on December 31, 1973.

PRICES

Engineering and Mining Journal, June through December 1973, quoted the following prices for feldspar, per short ton, f.o.b. mine or mill, carload lots, bulk, depending on grade (generally $1 per ton higher than the respective quotations of the previous year):

North Carolina:	
20 mesh, flotation	$13.00
40 mesh, flotation	14.00- 21.00
200 mesh, flotation	22.50- 23.50
325 mesh, flotation	27.00
Georgia:	
40 mesh, granular	21.00
200 mesh	25.50
325 mesh	26.50
Connecticut:	
20 mesh, granular	16.50
200 mesh	23.50
325 mesh	24.50

Feldspar prices were quoted by Industrial Minerals (London), December 1973, as follows (converted from pounds sterling per long ton to dollars per short ton):

Ceramic grade, powder, 200 mesh, bagged, ex-store	$41–$49
Lump, imported, c.i.f. main European port	21– 27

FOREIGN TRADE

In 1973, U.S. exports classified as feldspar, leucite, nepheline, and nepheline syenite (but presumably all or mostly feldspar) amounted to 9,554 short tons valued at $466,118, almost double the tonnage reported in 1972 and just over two and one-half times the value. Chief recipients of the exported material were Canada, 67%, and Mexico, 23%; the remaining 10% was shared among nine other countries. In marked contrast to rising exports of feldspar, U.S. imports of the mineral fell off notably in 1972 and dropped even more sharply in 1973, bringing this statistic to the lowest point since it was first separately recorded 50 years ago. In addition to feldspar and nepheline syenite (table

6), U.S. imports in 1973 included 850 tons of material, probably feldspathic in nature, that was classified as "Natural mineral fluxes, crushed, ground, or pulverized" and valued at $81,535.

The tariff schedule in force throughout 1973 provided for a 3½% ad valorem duty on ground feldspar; imports of crude feldspar were admitted duty free.

Table 4.—U.S. imports for consumption of feldspar

Country	1972		1973	
	Short tons	Value	Short tons	Value
Crude:				
Canada	187	$23,105	46	$3,725
South Africa, Republic of	--	--	218	17,870
Total	187	23,105	264	21,595
Ground, crushed, or pulverized:				
Canada	748	16,940	103	3,549
Sweden	49	1,742	--	--
United Kingdom	148	1,125	--	--
Total	945	19,807	103	3,549

WORLD REVIEW

An agency of the British Government issued a report tabulating world production and international trade statistics for many metals and industrial minerals for the years 1967 through 1971.[2] Based on that compilation, a rough ranking of countries according to apparent consumption of feldspar (exports subtracted from production plus imports) shows that in 1971 the United States was in first place, followed in descending order by West Germany, U.S.S.R., France, Italy, and the United Kingdom. Taking into account imported nepheline syenite and domestically produced aplite, U.S. apparent consumption of feldspathic materials in 1971 was more than 1 million tons and approximately three times the corresponding figure for second-place West Germany.

Canada.—Commercial production of feldspar in Canada was terminated, or at least suspended, in 1972, not because of any lack of exploitable mineral but as the result of a combination of unfavorable economic factors. Feldspar demand in Canada is not great—probably not over 8,000 tons per year—and the requirement most likely can be met with little difficulty by substitution of domestically produced nepheline syenite supplemented by limited quantities of imported mineral. In an article published in an industrial magazine, the Director of the Quebec Geological Exploration Service presented reasons, however, for concluding that a modestly profitable revival of the Canadian feldspar industry might be achieved with a limited expenditure of capital.[3]

Finland.—As is true in the United States, flotation concentrate now comprises the predominant part of Finland's feldspar production; hand-cobbed material, at one time the only form in which the mineral was recovered, amounted to less than 7% of Finland's 1972 total.

France.—French exports of feldspar outweighed imports in 1971, but only by a small margin; apparent consumption of the mineral thus came to slightly less than the figure of 212,000 tons reported for domestic production in that year.

Germany, West.—Feldspar consumption in West Germany in 1971 amounted to 477,000 tons, of which about four-fifths was supplied by domestic production and one-fifth was imported.

Italy.—Italy was a net exporter of feldspar in 1971 even though domestic consumption of the mineral accounted for almost 94% of the domestic production.

Kenya.—Although potentially workable deposits of feldspar are plentifully distributed throughout Kenya, the nonexistence of an export market, combined with the meagerness of internal demand (mostly for the manufacture of glass, ceramics, and scouring powder), acts to limit production to the efforts of a few small-scale operators. Government policy is now being aimed toward encouraging expanded development of this and other mineral resources by both national and foreign investors.

Rhodesia, Southern.—A consignment of material, shipped to the United States in July 1973 and listed as feldspar originating in the Republic of South Africa, was found to be petalite ore that had been mined in Southern Rhodesia. The importing firm, a large U.S. producer of alumi-

[2] Institute of Geological Sciences, Mineral Resources Division. Statistical Summary of the Mineral Industry—World Production, Exports and Imports 1967–1971. Her Majesty's Stationery Office (London), 1973, 407 pp.

[3] Maurice, O. D. Feldspar in Canada. Can. Min. and Met. Bull., v. 66, No. 738, October 1973, pp. 66–68.

Table 5.—Feldspar: World production, by country

(Short tons)

Country [1]	1971	1972	1973 [p]
North America:			
Canada (shipments)	10,774	11,684	[e] 12,000
Mexico	109,506	108,426	107,042
United States (sold or used)	742,810	732,439	791,900
South America:			
Argentina	39,996	70,801	[e] 71,000
Chile	992	1,771	[e] 1,800
Colombia	27,377	29,055	33,069
Peru	1,582	[r e] 1,650	[e] 1,650
Uruguay	1,332	1,070	226
Europe:			
Austria	2,928	3,391	2,296
Finland	70,616	65,982	64,285
France (crude)	212,000	162,000	[e] 165,000
Germany, West	389,879	385,198	338,432
Italy	212,192	193,805	209,657
Norway [2]	223,530	[r e] 220,000	[e] 220,000
Poland [e]	33,000	33,000	33,000
Portugal	20,691	19,854	[e] 20,000
Spain [3]	[r] 68,048	82,673	[e] 83,000
Sweden	30,541	37,579	[e] 37,500
U.S.S.R. [e]	276,000	287,000	298,000
United Kingdom (china stone)	69,248	58,422	53,809
Yugoslavia	59,103	53,280	[e] 55,000
Africa:			
Egypt, Arab Republic of	3,495	3,565	[e] 3,500
Kenya	2,921	2,163	1,610
Mozambique	(4)	(4)	--
Nigeria	NA	4,760	[e] 5,500
South Africa, Republic of	13,492	27,913	[e] 17,400
Zambia	--	--	13
Asia:			
Burma	[5] 766	881	[e] 900
Hong Kong	1,262	1,267	1,477
India	48,762	54,990	43,872
Japan [6]	57,843	63,662	56,766
Korea, Republic of	18,615	31,939	31,372
Pakistan	336	265	1,333
Philippines	61,539	50,774	27,556
Sri Lanka	284	638	[e] 640
Oceania: Australia	[r] 3,586	3,452	[e] 3,400
Total	[r] 2,815,046	2,805,349	2,794,005

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] In addition to the countries listed, Brazil, People's Republic of China, Czechoslovakia, Romania and Territory of South-West Africa produce feldspar, but available information is inadequate to make reliable estimates of output.

[2] Described in source as lump feldspar; does not include nepheline syenite as follows, in short tons: 1971—176,470; 1972—[e] 176,000; 1973—[e] 220,000.

[3] Includes pegmatite.

[4] Revised to zero.

[5] Data are for years ending June 30 of that stated.

[6] In addition the following quantities of aplite and saba were produced: Aplite: 1971—448,162; 1972—501,648; 1973—547,665; saba: 1971—6,005; 1972—1,336; 1973—NA.

num, was indicted on a charge of violating import sanctions against Southern Rhodesia.[4]

United Kingdom.—In 1972 the United Kingdom produced 58,000 tons of "china stone" and also imported 131,000 tons of feldspar (from Norway, Finland, Sweden, and Portugal) as well as 57,000 tons of nepheline syenite (Norway and Canada), compared with the figures of 69,000 tons, 131,000 tons, and 70,000 tons, respectively, in the preceding year. Exports of feldspathic materials in 1971 amounted to less than 2% of the total quantity involved, indicating that the United Kingdom's net annual consumption approaches a quarter of a million tons or about one-fourth of the corresponding figure for the United States.

TECHNOLOGY

The manufacturing of glass, especially container glass, has been for many years the largest outlet for feldspar in the United States. The modern technology of glassmaking was summarized in an article, part of which was devoted to the functions of the various raw materials involved and

[4] Industrial Minerals (London). "Feldspar" for Aluminum Production. No. 74, November 1973, p. 31.

dealt specifically with feldspar and nepheline syenite.[5]

Two other articles provided brief reviews of the advancing technology of container glass manufacturing as well as some forecast of the effects upon that industry that can be expected from the rapidly changing energy and environmental situations.[6] A paper presented at the 1973 annual meeting of the Society of Mining Engineers (Chicago, February 25–March 1, 1973) discussed factors to be considered in compensating for changes in glass furnace feed materials including feldspar, nepheline syenite, aplite, and feldspathic sands.[7]

A number of notes in industrial journals dealt with investigations and developments that, by leading to the evolution of stronger and lighter glass containers, may at least indirectly affect the feldspar industry.[8]

Bureau of Mines participation in the recycling of waste glass during 1973 included research on the production of concrete blocks, roof slabs, and curtain walls based on a novel type of lightweight aggregate in which the principal ingredient was waste glass. Bureau scientists were invited to present a paper on an allied subject before the Society of Mining Engineers at the annual meeting in February 1974 at Dallas, Tex.[9] Financial considerations involved in reutilization schemes for salvaged waste glass were explored in a Bureau publication.[10]

The Glass Container Manufacturers Institute announced the start of construction at Franklin, Ohio, of the world's first waste glass reclamation plant. The facility, designed to subject an entering stream of municipal solid waste to the most modern techniques of treatment by high-intensity magnetism, air currents, screening, and optical sorting, will separate 4 tons of glass per day in a form suitable for remelting to make new containers.[11] In Denver, Colo., a picnic pavillion for a city park was constructed with so-called ecological panels formed by mixing rubble from demolished buildings with a large proportion of salvaged container glass. This novel building material, in a variety of textures and color combinations, was described as being attractive in appearance and highly resistant to weathering while providing an advantageous outlet for what otherwise would have been a burdensome accumulation of rubbish.[12]

Research carried out in England demonstrated the suitability of cement reinforced with coarsely crushed waste glass for such components as drain pipes, sewer linings, bridge decking, and marine hulls.[13] In a related application, recycled glass was crushed and then blended with a liquid plastic monomer into a mixture that was cured in molds to form lengths of sewer pipe. This sewer pipe was stronger than the conventional product and potentially competitive with it on a technical and economic basis. It was not found necessary to color sort the waste glass nor to free it from accompanying labels and metal cap rings.[14] The Midwest Research Institute, continuing an examination of various potentially profitable utilizations of waste glass in the building industry, undertook a study of ceramic foams and tile produced by firing mixtures of salvaged glass with dried residues from animal feedlots.[15]

Glasphalt is the name given to a street paving mixture composed of asphalt and crushed glass first introduced several years ago. Additional research on this material at the University of Missouri at Rolla

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[5] Industrial Minerals (London). An Introduction to the Glass Industry. No. 74, November 1973, pp. 9–10, 12–13, 15, 17–19, 21–23.

[6] Fabianic, W. L. The Future of the Glass Container Industry. Ceram. Ind., v. 100, No. 4, April 1973, pp. 72–74.
Industry Week. More and More Soft Drinks in Nonreturnable Containers. V. 179, No. 4, July 23, 1973, pp. 50, 52.

[7] Kephart, W. W. Glass Containers From Varying Industrial Mineral Sources. Soc. Min. Eng., AIME, Preprint No. 73-H-21, 10 pp.

[8] LaDue, A. W. Improving Glass Container Strength. Ceram. Ind., v. 100, No. 3, March 1973, p. 28.
Arrendale, R. Plastic Coated Bottles Make Inroads. Ceram, Ind., v. 101, no. 4, October 1973, pp. 50–51.
Materials Engineering. Powder Coated Glass. V. 77, No. 6, June 1973, p. 53.
The Glass Industry. New Coke Bottles Move to Market. V. 54, No. 11, October 1973, p. 26.

[9] Goode, A. H., and M. E. Tyrell. Utilization of Waste Glass in Clay Brick. Soc. Min. Eng., of AIME, Preprint No. 74-H-43, 12 pp.

[10] Johnson, P. W., and J. A. Barclay. Economic Studies of Uses of Glass Fractions From Municipal Incinerator Residues. BuMines IC 8567, 1973, 44 pp.

[11] American Ceramic Society Bulletin. Glass Reclamation Plant Under Construction. V. 52, No. 1, January 1973, p. 152.

[12] The Glass Industry. Recycled Glass Builds Civic Pride. V. 54, No. 2, February 1973, p. 17.

[13] Rock Products. Glass-Reinforced Cement Makes Gains Abroad. V. 76, No. 11, November 1973, p. 17.

[14] Ceramic Age. Waste Glass Makes Debut as Sewer Pipe. V. 89, No. 3, March 1973, p. 5.

[15] Environmental Science & Technology. Technology. V. 7, No. 5, May 1973, p. 389.

showed that it was permissible as well as economical to use for this purpose waste glass that had not been subjected to a complete and costly separation from foreign solids. It was found that an acceptable and serviceable pavement could be prepared by mixing asphalt with the glass-rich fraction of the original residue even when that fraction still contained as much as 17% of a miscellany of metals, plastics, stones, bones, and ceramics.[16]

The fluxing action of feldspar or other feldspathic materials was the basis for the enamels, frits, and glazes developed by the ceramists of ancient Egypt and continues to be of fundamental importance in most of those products in use today. The intricate technology of glazes and of their utilization were among the principles considered in a newly published book.[17] A radically new technique is being developed in the field of porcelain enamels, and an article was published discussing problems involved in applications of that innovation.[18]

The first white-burning body for ceramic wall tile on record as produced in the United States was of the classic clay-flint-feldspar type and most likely was compounded entirely from imported materials. Cornwall stone from England, the feldspathic material first used here in tile bodies, eventually yielded its place to Vermont feldspar, which was superseded in turn by feldspar from the large deposits of North Carolina. In more recent formulations, the tendency has been to replace at least part of the feldspar in this application by talc, pyrophyllite, or wollastonite. The changing technology of ceramic tile body mixtures was reviewed in a journal article.[19]

One of the less publicized applications for feldspar is in the production of porcelain for artificial dentures. Porcelain acceptable for this specialized service must combine to an extraordinary degree the properties of pleasing appearance and physical strength with the ability to resist chipping and abrasion. Porcelain used in dentures must also remain chemically stable for many years under conditions of frequent or prolonged contact with a wide variety of solid substances and liquids, some of which are quite vigorous solvents. A journal article described the sophisticated techniques by which one manufacturer turns out natural-appearing porcelain teeth from carefully chosen raw materials including a select grade of potash feldspar from Wyoming.[20]

A number of research papers were published relating to various types of feldspar and summarizing investigations that may provide bases for advances in the practical utilization of those minerals.[21]

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[16] Ceramic Age. Unrefined Glass Used for Glasphalt. V. 89, No. 1, January 1973, p. 4.

[17] Rhodes, D. Clay and Glazes for the Potter. Chilton Book Co., Philadelphia, Pa., 1973, 330 pp.

[18] Hein, G. Electrostatic Deposition of Powdered Frit. Ceram. Ind., v. 100, No. 3, March 1973, pp. 20–21.

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[20] Ceramic Age. Dentsply—Advocate of Top Flight Materials Engineering. V. 89, No. 10, October 1973, pp. 1, 8–10.

[21] Barros Gomes, C. de. Chemical Changes in Plagioclases and Their Bearing on the Petrologic History of an Amphibolite Body. Am. Miner., v. 57, Nos. 11–12, November–December 1973, pp. 1860–1870.

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NEPHELINE SYENITE

Nepheline syenite, a rock of igneous origin with a texture similar to that of granite, consists essentially of a mixture of nephelite with varying proportions of the alkali feldspars. Nepheline syenite found thus far in the United States has been of a quality suitable only for use as crushed stone, but an immense deposit in Canada (Blue Mountain, Ontario) has provided the United States with an abundance of imported material of higher grade. The Canadian material serves advantageously in glassmaking as an alumina-bearing ingredient in furnace feeds, in the whiteware industry either as a body component or as a fluxing agent in glazes, and increasingly in recent years as a filler for plastics, latex, paints, and paper. U.S. imports of Canadian nepheline syenite, which were first reported in the mid-1930's, have increased in all but a few of the years since, and now appear to be rising on a steepening curve. Starting at 10,000 tons per year (tpy) or less in 1936, the figure climbed to 100,000 tpy by 1955, to 200,000 tpy by 1964, to 300,000 tpy by 1968, and to 400,000 tpy by 1971. Further substantial increases in 1972 and 1973 have brought the half-million-ton-per-year mark well within sight. Under the present U.S. tariff schedule, imports of nepheline syenite, crude or ground, are admitted duty free.

The price range quoted for nepheline syenite in Ceramic Industry Magazine, January 1974, was from $10.25 to $23.40 per ton. Price ranges for this commodity listed in Industrial Minerals (London), December 1973, were equivalent (with a minor degree of uncertainty because of the floating sterling/dollar exchange rate) to the following:

Canadian, bagged ex-store:	
Glass grade, 30-mesh, 10-ton lots	$41–$47
Ceramic grade, 200 or 325-mesh, small lots	57– 65
Norwegian, ex-store:	
Glass grade, 32-mesh (Tyler), bulk	30– 33
Ceramic grade, 325-mesh (Tyler), bagged	43– 49

A British publication tabulated available data on world production, exports, and imports of nepheline syenite, 1967 through 1971.[22]

Table 6.—U.S. imports for consumption of nepheline syenite

Year	Crude		Ground	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1971	636	$12	413,862	$4,912
1972	3,027	43	456,406	5,681
1973	258	4	473,838	6,022

APLITE

Aplite is a granitic rock with a high proportion of albite (soda feldspar) or plagioclase (lime-soda feldspar), either of which makes it potentially useful as a raw material for the manufacture of container glass. To become acceptable for that purpose, however, the mined material usually must be processed to eliminate most of the iron-bearing substances it commonly contains. Aplite of glassmaking quality was produced in the United States in 1973 from two open pit mines in central Virginia. The Feldspar Corp. mined aplite ore near Montpelier, Hanover County, and removed iron from it by an electrostatic process. Sobin Chemicals, Inc., an affiliate of International Minerals & Chemical Corp., operated a mine near Piney River, Nelson County, and subjected the crude aplite to a high-intensity magnetic separation to eliminate iron minerals. Tonnage and total value of the 1973 output, respectively 5% and 61% above the corresponding figures for 1972, were the highest on record.

Specific annual data on aplite production, sales, and value have not been released for publication since 1962. The output for 1962 amounted to 140,000 short tons, valued at $0.9 million. The price range for aplite quoted in Ceramic Industry Magazine, January 1974, was from $12.70 to $13.00 per ton, compared with $6.30 to $12.40 per ton quoted in January 1973.

[22] Page 400 of workcited in footnote 2.

Ferroalloys

By Norman A. Matthews [1]

The overall structure of the domestic ferroalloy industry did not change basically during 1973. The abnormally high demand for ferroalloys resulted in capacity production throughout most of the year; nevertheless shortages persisted for ferrosilicon and some manganese alloys. Two older plants, scheduled to close because of emission control equipment costs, were purchased by new owners and granted another year to install emission controls. Most producers had made provisions for emission control facilities and expenditures for such capital improvements continued at a high level.

Ferroalloy exports nearly doubled as world demand exceeded capacity. Imports continued to increase substantially, but the rate of imports decreased somewhat late in the year as imports from Western Europe and Japan declined.

Prices increased generally in the first quarter and then remained essentially static during the balance of the year under phase IV price controls. Dual level (two-tier) pricing developed in some silicon alloys as the smaller producers were permitted price increases justified by cost increases.

Detailed information concerning utilization of individual elements in various alloy products can be found in the chromium, manganese, silicon, molybdenum, nickel, tungsten, and vanadium chapters.

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Table 1.—Government inventory of ferroalloys (stockpile grade), December 31, 1973

(Thousand short tons)

Alloy	National (strategic) stockpile	CCC and supplemental stockpile	Total
Ferrochromium:			
High-carbon	126	276	402
Low-carbon	128	191	319
Ferrochromium-silicon	26	32	58
Ferrocolumbium (contained columbium)	0.5	--	0.5
Ferromanganese:			
High-carbon	126	985	1,111
Medium-carbon	29	--	29
Ferromanganese-silicon	23	--	23
Ferromolybdenum (contained molybdenum)	2.5	--	2.5
Ferrotungsten (contained tungsten)	1	--	1
Ferrovanadium (contained vanadium)	1	--	1

Table 2.—Ferroalloys produced and shipped from furnaces in the United States

	1972				1973			
	Production		Shipments		Production		Shipments	
	Gross weight (short tons)	Alloy element contained (average percent)	Gross weight (short tons)	Value (thousands)	Gross weight (short tons)	Alloy element contained (average percent)	Gross weight (short tons)	Value (thousands)
Ferromanganese [1]	800,723	78.3	726,592	$126,598	683,075	78.8	779,459	$136,907
Silicomanganese	153,234	65.3	146,433	28,440	183,702	66.3	195,956	39,439
Ferrosilicon [2]	841,386	59.8	784,399	182,100	877,798	58.0	906,542	243,151
Silvery pig iron	163,073	20.8	163,714	14,800	135,009	22.0	156,287	14,969
Chromium alloys:								
Ferrochromium:								
High-carbon	169,525	65.0	162,718	39,688	241,667	66.8	261,624	73,055
Low-carbon	69,003	69.1	81,043	38,581	88,085	69.4	104,329	45,988
Ferrochromium:								
Silicon	98,223	42.4	90,986	25,974	80,788	36.8	89,799	26,743
Other alloys [3]	15,554	53.0	17,293	7,031	16,306	43.9	16,816	10,788
Total	352,305	62.0	352,040	111,274	426,846	60.8	472,568	156,574
Ferrotitanium	3,650	25.7	4,133	4,566	1,784	39.9	2,176	2,417
Ferrophosphorus	130,355	23.9	118,454	5,739	129,646	16.5	143,257	7,681
Ferrocolumbium	1,160	63.5	2,431	11,656	1,167	64.1	2,758	15,316
Other [4]	80,738	44.2	81,598	82,416	80,928	39.0	96,799	104,088
Grand total	2,526,624	61.8	2,379,794	567,589	2,519,955	60.0	2,755,802	720,542

[1] Includes briquets and fused-salt electrolytic.
[2] Includes silicon metal and inoculant type alloys.
[3] Includes chromium briquets, chromium metal, exothermic chromium additives, and other miscellaneous chromium alloys.
[4] Includes ferroboron, and other complex boron additive alloys, ferronickel, ferromolybdenum, ferrotungsten, ferrovanadium, spiegeleisen, ferrozirconium, and other miscellaneous alloys.

DOMESTIC PRODUCTION

The number of ferroalloy producers increased by 1 to 26 during the year as the Steubenville, Ohio, plant of Foote Mineral Co. was sold to Satra Corp. at yearend. Subsequently Satra Corp. announced that a large furnace would be added to produce charge chromium and that an overall plant modernization would be carried out to incorporate emission control facilities. At yearend Hanna Mining Co. purchased the Wenatchee, Wash., plant of Foote Mineral Co. which Foote had scheduled for closing. Of the 26 producing companies, 6 produced ferrophosphorus in 9 plants as a byproduct of phosphorus production. Reynolds Metals Co. announced the expansion of its captive silicon metal facility at Sheffield, Ala.; a second furnace will raise capacity from 7,000 to 17,000 tons per year with startup scheduled in 1975.

Steel, cast iron, and aluminum production were at record levels in 1973 and demand for ferroalloys increased proportionately. The ferroalloy industry operated at capacity, but because of extraordinary demand and a decline in imports of some categories of alloys, shortages of manganese and silicon alloys persisted throughout the last 6 to 8 months of the year. Substantial shipments of ferromanganese from the Government stockpile (65,000 tons) minimized the seriousness of the manganese shortage. Price controls under phase IV exaggerated the shortage of some alloys as producers concentrated on higher value alloys. An example was the continued shortage of 50% ferrosilicon grade traditionally utilized by foundries. Overall shipments of manganese, silicon, and chromium alloys increased by 12%, 16%, and 34%, respectively, compared with 1972 figures and producers inventories were reduced to low levels at yearend. Since no new ferroalloy capacity is scheduled until late 1974, the shortage of manganese and silicon alloys will probably persist as long as steel and foundry industries continue operating at capacity.

Several new ferroalloy facilities were planned or under construction. Northwest Alloys, Inc., a subsidiary of the Aluminum Company of America, completed plans for a magnesium and silicon alloy facility at Addy, Wash. but initial construction was delayed by environmental considerations. The Magnétherm process, developed in France, will be utilized. It involves the reduction of calcined dolomite by ferrosilicon in the presence of alumina under reduced pressure. The volatilized magnesium collects in an auxiliary chamber. The silicon alloy will be produced conventionally in a submerged arc furnace. Startup will be delayed until 1976.

Foote Mineral Co. announced the installation of a new 20-megawatt electric furnace, auxiliary air pollution control equipment, and modernization throughout its Graham, W. Va., plant. The new furnace, principally for silicon alloys, and modernization were estimated to cost $6.9 million with completion scheduled in mid-year 1975. Ohio Ferro-Alloys Corp. scheduled, for 1975, the installation of a modern 46-megavolt-ampere (MVA) furnace for silicon alloy production at its Philo, Ohio, plant. The furnace and a modularly constructed baghouse, designed by Ohio Ferro-Alloys, are estimated to cost $4.0 million. Union Carbide Corp. planned a new furnace for silicon alloys at its Alloy, W. Va., plant. Startup was anticipated for late 1974.

Tenn-Tex Alloy Corp. of Houston, Tex., announced plans for the installation of a second ferromanganese furnace of 35 MVA transformer capacity that will increase plant capacity 50,000 to 60,000 tons per year. Operation of the new furnace is scheduled for 1975. The National Metallurgical Division of Kawecki Berylco Industries announced a capital expansion program to cost $5.5 million which will double the productive capacity of its silicon plant at Springfield, Oreg. Construction was to begin early in 1974 and was to be completed in the first half of 1975.

Table 3.—Producers of ferroalloys in the United States in 1973

Producer	Plant location	Product[1]	Type of furnace
Airco Alloys & Carbide	Calvert City, Ky Charleston, S.C Mobile, Ala Niagara Falls, N.Y	FeCr, FeCrSi, FeMn, FeSi, SiMn.	Electric.
Bethlehem Steel Corp	Johnstown, Pa	FeMn	Blast.
Chromium Mining & Smelting Co.	Woodstock, Tenn	FeCr, FeSi, FeCrSi.	Electric.
Climax Molybdenum Co	Langeloth, Pa	FeMo	Aluminothermic.
Diamond Shamrock Corp	Kingwood, W.Va	Mn	Electric.
FMC Corp	Pocatello, Idaho	FeP	Do.
Foote Mineral Co	Cambridge, Ohio Graham, W.Va Keokuk, Iowa Steubenville, Ohio Wenatchee, Wash	FeB, FeCb, FeTi, FeV, FeCr, FeCrSi, FeSi, silvery iron, other.[2]	Do.
Hanna Nickel Smelting Co	Riddle, Oreg	FeNi	Do.
Hooker Chemical Corp	Columbia, Tenn	FeP	Do.
Interlake Steel Corp	Beverly, Ohio Selma, Ala	FeCr, FeCrSi, FeSi, SiMn.	Do.
Kawecki Berylco Industries	Springfield, Oreg	Si	Do.
Kawecki Chemical Co	Easton, Pa	FeCb	Aluminothermic.
Mobil Chemical Co	Nichols, Fla	FeP	Electric.
Molybdenum Corp. of America	Washington, Pa	FeMo, FeW, FeCb, FeB.	Electric and aluminothermic.
Monsanto Chemical Co	Columbia, Tenn Soda Springs, Idaho	FeP	Electric.
New Jersey Zinc Co	Palmerton, Pa	Spln	Do.
Ohio Ferro-Alloys Corp	Brilliant, Ohio Philo, Ohio Powhatan, Ohio	FeCr, FeSi, FeB, FeMn, SiMn, others.[2]	Do.
Reading Alloys	Robesonia, Pa	FeCb, FeV	Aluminothermic.
Shieldalloy Corp	Newfield, N.J	FeV, FeTi, FeB, FeCb, NiCb, CrMo, other.[2]	Do.
Stauffer Chemical Co	Tarpon Springs, Fla Mt. Pleasant, Tenn Silver Bow, Mont	FeP	Electric.
Tennessee Alloys Corp	Bridgeport, Ala Kimball, Tenn	FeSi	Do.
Tennessee Valley Authority	Muscle Shoals, Ala	FeP	Do.
Tenn-Tex Alloy Corp. of Houston.	Houston, Tex	FeMn, SiMn	Do.
Union Carbide Corp	Alloy, W.Va Ashtabula, Ohio Marietta, Ohio Niagara Falls, N.Y Portland, Oreg Sheffield, Ala	FeB, FeCr, FeCrSi, FeCb, FeSi, FeMn, FeTi, FeW, FeV, SiMn, other.[2]	Do.
U.S. Steel Corp	Clairton, Pa McKeesport, Pa	FeMn	Blast.
Woodward Iron Co	Woodward, Ala Rockwood, Tenn	FeSi, FeMn, SiMn.	Electric.

[1] CrMo, Chromium molybdenum; FeMn, ferromanganese; Spln, spiegeleisen; SiMn, silicomanganese; FeSi, ferrosilicon; FeP, ferrophosphorus; FeCr, ferrochromium; FeMo, ferromolybdenum; FeNi, ferronickel; FeTi, ferrotitanium; FeW, ferrotungsten; FeV, ferrovanadium; FeB, ferroboron; FeCb, ferrocolumbium; NiCb, nickel columbium; Si, silicon metal.
[2] Includes zirconium alloys, ferrosilicon magnesium, calcium silicon, and miscellaneous ferroalloys.

CONSUMPTION AND USES

Record raw steel production of 150.8 million tons and cast iron production of 18.1 million tons consumed record quantities of ferromanganese and silicon alloys. Aluminum castings production at a level of 1.0 million tons in 1973 also required a record quantity of silicon metal for alloying. Reported consumption of manganese alloys was 1,173,458 tons, an increase of 15% compared with 1972 totals whereas the steel and cast iron production increase in volume was 13% compared with 1972 production. Reported total silicon alloy consumption was 1,164,723 tons, an increase of 24% compared with that of 1972, a higher increase than would be expected from the 12% increase in cast iron and 7% increase in aluminum castings production. The additional requirements may well reflect a higher percentage of silicon killed steel production in the wrought steel total associated with the continuous casting process. Consumption of ferrotitanium and other forms of titanium for alloying and deoxidizing of steel almost doubled as formable high-strength steels became more widely accepted for automotive applications.

Chromium, molybdenum, and nickel consumption for stainless and alloy steels and other special alloys increased proportionately to the record production of these alloys in 1973. Chromium consumption increased 32% compared with that of 1972, molybdenum as ferromolybdenum increased 17%, and nickel as ferronickel increased 59%.

Consumption data for the alloying elements listed in table 5 understate total consumption of several elements since these data cover only the ferroalloy forms. The alloying elements nickel, molybdenum, tungsten, and vanadium may be added to metallic melts in any one of several forms. The practice varies as relative economics change and technological progress permits greater latitude in the choice of form of the alloying addition.

Table 4.—Consumption by end use of ferroalloys as additives in the United States in 1973

(Short tons of alloys)

Alloy	Stainless steels	Other alloy steels	Carbon steels	Tool steels	Cast irons	Superalloys	Alloys (excludes alloy steels and superalloys)	Other uses [1]	Total
Ferromanganese [2]	17,924	192,374	904,893	2,474	30,673	689	21,042	3,389	1,173,458
Silicomanganese	12,458	39,092	94,630	51	4,907	W	2,785	5,096	159,019
Silicon alloys [3]	30,964	102,662	183,308	4,023	704,373	586	89,417	49,390	1,164,723
Ferrotitanium [4]	970	1,153	3,753	W	124	583	2,075	2,488	11,146
Ferrophosphorus [5]	16	1,860	13,476	--	5,772	--	270	7,868	29,262
Ferroboron	13	325	27	--	9	W	54	1	429
Total	62,345	337,466	1,200,087	6,548	745,858	1,858	115,643	68,232	2,538,037

W Withheld to avoid disclosing individual company confidential data; included in "Other uses."
[1] Includes unspecified uses.
[2] Includes spiegeleisen, manganese metal, and briquets.
[3] Includes silicon metal, silvery iron, and inoculant alloys.
[4] Includes other forms such as scrap titanium metal.
[5] Includes other phosphorus materials.

Table 5.—Consumption by end use of ferroalloys as alloying elements in the United States in 1973

(Short tons of contained elements)

Alloy	Stainless steels	Other alloy steels	Carbon steels	Tool steels	Cast irons	Superalloys	Alloys (excludes alloy steels and superalloys)	Other uses [1]	Total
Ferrochromium [2]	228,096	54,586	2,358	4,611	7,661	9,914	5,096	3,347	315,669
Ferromolybdenum [3]	982	1,032	132	651	1,665	240	480	70	5,252
Ferrotungsten [4]	67	64	--	737	W	76	36	2	982
Ferrovanadium [5]	22	3,779	680	991	51	34	32	11	5,600
Ferrocolumbium	320	769	483	W	--	288	16	21	1,897
Ferrotantalum-columbium	W	W	--	--	--	W	W	20	20
Ferronickel	27,837	6,562	--	--	414	476	390	692	36,371
Total	257,324	66,792	3,653	6,990	9,791	11,028	6,050	4,163	365,791

r Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Includes unspecified uses.
[2] Includes other chromium ferroalloys and chromium metal.
[3] Includes calcium molybdate but not molybdenum oxide.
[4] Includes melting base self-reducing tungsten.
[5] Includes other vanadium-carbon-iron ferroalloys.

The following tabulation gives the proportion of the alloying elements added in the ferroalloy state in relation to other product forms. It refers only to metallic products, omitting chemicals and other end uses.

Element	Added as ferroalloy [1] (Percent)	Added in other forms (Percent)
Molybdenum	28	72
Nickel	20	80
Tungsten	28	72
Vanadium	90	10

[1] Modified as in notes to table 5.

STOCKS

Producers stocks decreased substantially at yearend compared with stocks at the end of 1972 as might be expected in a period of great demand and scarcity in some alloys. Yearend silicon, manganese, and chromium alloy stocks decreased 68%, 50%, and 56% respectively, compared with stocks at the end of 1972. Consumer stocks of chromium and silicon alloys showed a modest increase whereas manganese alloys showed a slight decline. Consumer stocks of the alloying elements molybdenum, nickel, and vanadium showed the greatest percentage increase amounting to 39%, 95%, and 82% respectively.

Table 6.—Stocks of ferroalloys held by producers and consumers in the United States, December 31, 1973

(Short tons)

	Producer		Consumer	
	1972, gross weight	1973, gross weight	1972, gross weight	1973, gross weight
Manganese ferroalloys [1]	244,635	122,098	194,884	180,242
Silicon alloys [2]	130,637	41,800	133,581	145,413
Ferrochromium [3]	86,302	37,690	27,422	48,456
Ferrotitanium [4]	1,163	505	1,206	7,622
Ferrophosphorus [5]	59,226	52,325	4,173	5,536
Ferroboron	413	286	47	91
Total	522,376	254,704	361,313	387,360
	1972, contained element	1973, contained element	1972, contained element	1973, contained element
Ferromolybdenum [6]	W	W	793	1,105
Ferronickel	W	W	3,990	7,792
Ferrotungsten [7]	W	W	145	170
Ferrovanadium	r 841	271	623	1,135
Ferrocolumbium	r 318	340	407	728
Total	r 1,159	611	5,958	10,930

r Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Includes ferromanganese, siliconmanganese, spiegeleisen, and manganese metals.
[2] Includes ferrosilicon, silvery iron, silicon metal, and miscellaneous silicon alloys.
[3] Includes other chromium ferroalloys and chromium metal.
[4] Includes other titanium materials.
[5] Includes other phosphorus materials.
[6] Includes calcium molybdate.
[7] Includes melting base self-reducing tungsten.

PRICES

Prices of manganese alloys were raised in April from $190 to $200 per gross ton for 78% high carbon ferromanganese; from 19.5 to 20 cents per pound for medium carbon ferromanganese; from 30.5 to 32.5 cents per pound for low-carbon ferromanganese. Prices of ferromanganese-silicon and other more specialized types were increased similarly.

Prices on several important chromium alloys were increased 1 to 2 cents per pound contained in March although prices were not published generally. Phase IV price controls then applied throughout the balance of the year and little additional price movement resulted. At yearend charge chromium (64% to 67%) was quoted at 20 cents and low-carbon ferrochromium (0.05 maximum carbon) at 33 cents per pound contained Cr.

Ferrosilicon price movement began in March and was reflected in an increase in published prices in April, for example, 50% ferrosilicon advanced from 15 to 16.5 cents per pound and 75% ferrosilicon advanced from 18.5 to 20 cents per pound. Two-tier pricing under Phase IV controls persisted during much of the second half of the year with the range of quoted prices embracing the earlier and later price ranges. Prices of magnesium ferrosilicon, ferrocolumbium, ferrotungsten, ferrovanadium, and ferromolybdenum remained unchanged during the year.

Costs of production increased substantially during the year due to: (1) power cost increases; (2) increased prices for scrap iron and other supplies; and (3) increased labor costs. However, Phase IV price controls prevented general price increases.

FOREIGN TRADE

Quantity of U.S. exports of ferroalloys increased substantially in 1973 compared with 1972 as demand by the steel industries of the world increased. Canada was the largest overall customer for U.S. ferroalloy exports, involving principally ferromanganese, ferrochromium, and ferrovanadium. Japan was second with respect to value of U.S. ferroalloys purchased, principally for ferromolybdenum. The overall tonnage exported increased from 44,641 tons in 1972 to 83,669 tons in 1973 and was valued at $33.8 million.

In general, imports continued to increase during 1973, although the rate of imports declined later in the year as Japan and some Western European countries reduced exports to the U.S. Overall tonnage of imports increased 26% compared with that of 1972 and value increased 39% compared with that of 1972. The largest increases were in the tonnage grades: (1) High-carbon ferromanganese; (2) high-carbon ferrochromium; (3) 75% ferrosilicon; and (4) ferrosilicon-manganese. Imports of nickel in ferronickel doubled, and the value of ferronickel imported was the largest of any single alloy at $70.5 million.

The Republic of South Africa was the dominant ferroalloy exporter to the U.S. market.

In chromium alloys, shipments to the United States ranked by value were from: (1) Republic of South Africa; (2) Southern Rhodesia; (3) Japan; and (4) Sweden. In ferromanganese, receipts were from: (1) Republic of South Africa; (2) France; (3) India; and (4) Japan. The value of silicon alloys imported more than doubled and was dominated by receipts from: (1) Norway; (2) France; (3) Canada; and (4) Yugoslavia. Spain, Yugoslavia and Greece became significant factors for the first time in ferroalloy exports to the United States; exports of ferromanganese from Spain will probably decline as new steelmaking capacity goes into operation there in 1975–76. The miscellaneous category of imports (n.e.c.) was dominated by ferrocolumbium imports from Brazil.

On May 4, 1973, the domestic ferroalloy industry petitioned the U.S. Tariff Commission for relief from imported alloy competition. The Ferroalloys Association, a 12-member group representing U.S. producers, submitted its request for higher duties, import quotas, or both, under Section 301(A) of the Trade Expansion Act of 1962. However, a few weeks later the association requested its bid be withdrawn with the unexpected steel and alloy demand that developed quickly. The commission agreed, cancelling scheduled hearings without prejudice to potential future actions.

Free world prices of ferroalloys increased substantially during 1973 whereas, except for silicon alloys, prices in the United States were under government control. By yearend considerable free market volume was diverted to countries other than the United States where higher prices and lower transportation costs prevailed.

Table 7.—U.S. exports of ferroalloys

Alloys	1971 Quantity (short tons)	1971 Value (thousand dollars)	1972 Quantity (short tons)	1972 Value (thousand dollars)	1973 Quantity (short tons)	1973 Value (thousand dollars)
Ferrocerium and alloys	30	164	101	610	55	286
Ferrochromium	9,164	3,620	12,861	4,342	15,164	5,091
Ferromanganese	4,526	1,205	6,842	1,512	8,574	2,137
Ferromolybdenum	677	1,978	454	1,163	1,112	3,151
Ferrophosphorus	35,111	1,419	1,179	111	19,030	773
Ferrosilicon	25,506	5,603	7,367	2,196	15,984	4,051
Ferrotungsten	60	411	11	85	6	50
Ferrovanadium	1,351	3,490	269	1,256	1,416	8,734
Ferroalloys, n.e.c	10,905	5,249	15,557	8,495	22,328	9,485
Total	87,330	23,139	44,641	19,770	83,669	33,758

Table 8.—U.S. imports for consumption of ferroalloys and ferroalloy metals

Alloy	1972 Gross weight (short tons)	1972 Content (short tons)	1972 Value (thousand dollars)	1973 Gross weight (short tons)	1973 Content (short tons)	1973 Value (thousand dollars)
Chromium metal	1,894	(1)	3,791	2,690	(1)	6,080
Ferrocerium and other cerium alloys	14	(1)	94	19	(1)	127
Ferrochromium:						
Containing 3% or more carbon	73,077	44,017	11,266	112,197	69,534	18,253
Containing less than 3% carbon	68,194	46,249	23,322	43,344	30,224	16,922
Ferromanganese:						
Containing less than 1% carbon	3,192	2,703	1,195	1,939	1,595	810
Containing over 1% and less than 4% carbon	55,066	44,889	13,125	46,243	37,496	10,919
Containing 4% or more carbon	290,281	227,125	35,526	342,185	264,776	41,579
Ferronickel	51,741	13,244	35,857	89,780	25,700	70,532
Ferrosilicon:						
8% to 60% silicon	14,525	4,824	3,054	23,979	7,257	3,657
60% to 80% silicon	24,920	18,182	5,714	75,519	55,750	17,364
80% to 90% silicon	--	--	--	396	343	47
Over 90% silicon	155	148	47	39	38	19
Ferrosilicon-chromium	8,427	(1)	1,846	13,037	(1)	3,127
Ferrosilicon-manganese (Mn content)	38,674	25,901	4,828	44,759	30,061	6,367
Ferrotitanium and ferrosilicon titanium	91	(1)	76	256	(1)	178
Ferrotungsten and ferrosilicon tungsten	508	407	2,169	696	553	3,105
Ferrovanadium	454	334	2,007	277	196	1,174
Ferrozirconium	2,604	(1)	1,159	1,249	(1)	627
Ferrophosphorus	308	(1)	15	--	--	--
Ferroalloys, n.e.c	1,668	(1)	4,766	2,246	(1)	6,719
Manganese metal	4,121	(1)	1,675	2,452	(1)	1,100
Silicon metal (less than 99.7% silicon)	3,523	3,467	1,346	7,939	7,588	3,509
Total	643,437	XX	152,878	811,241	XX	212,215

r Revised. XX Not applicable.
[1] Not recorded.

WORLD REVIEW

Table 9 lists ferroalloy production in the world by country and furnace type for the years 1971 through 1973 from the most reliable sources. Production increased substantially overall as the steel industries of the world operated at capacity levels. The International Iron and Steel Institute reported steel production increased 10% in 1973 compared with 1972 production for the 24 countries reporting. The tabulated ferroalloy production figures show a more modest increase of 6.5% but, as in the United States, producers' inventories were reduced substantially at yearend so that shipment figures, if available, would correlate more closely with the increase in steel production.

New ferroalloy projects announced during 1973 are listed in the paragraphs that follow:

Australia.—Garrick Agnew Pty., Ltd., announced plans for a vanadium oxide facility at Wundowie near Perth involving roasting, leaching, and pelletizing to produce 3,500 tons per year of vanadium pentoxide. British Oxygen Ltd. and Mitsui Co. Ltd. each have a 20% interest in the project. Operation is projected late in 1975 or early in 1976.

Canada.—Copperfields Mining Corp., Ltd., and Quebec Mining Exploration Co. announced financing had been arranged for mining and concentrating facilities at Chicoutimi, Quebec, to process 1,500 tons per day of ore containing 0.76% Cb_2O_5. Ore reserves are estimated at 40,000,000 tons and startup is planned in 1975. The columbium oxide product is to be marketed in Europe, Japan, and the United States.

Greece.—The Japanese companies Tekkosha Co., Ltd., and Mitsubishi Chemical Industries, Ltd., signed an agreement with the Government of Greece to construct a $17 million, 12,000-ton-per-year plant to produce manganese dioxide electrolytically for dry cell batteries. The plant, scheduled for operation in mid-1975, will use manganese ore from the Chalkidiki area and can be expanded to a total capacity of 36,000 tons per year at a later date.

Iceland.—Union Carbide Corp. announced an agreement with the Government of Iceland for the construction of a $28 million ferrosilicon plant at Hvalfjördhar on the west coast. The plant, to be financed 65% by the Government of Iceland and 35% by Union Carbide, will have a capacity of 50,000 tons per year of 75% ferrosilicon and is expected to be operational by early 1976. Power will be provided from a new hydroelectric powerplant being constructed at Sigalda.

India.—The Industrial Development Corporation of Orissa, Orissa Province, announced a new ferrovanadium project. The facility, estimated to cost $15.6 million, involves mining, concentrating, and reduction facilities to provide 480 tons per year of ferrovanadium. Startup date has not been announced but the project is included in a 5-year plan beginning in 1974.

Mexico.—Cia. Minera Autlan S.A. de C.V. of Mexico has placed a contract for $15.5 million with Japan Metals and Chemicals Co., Ltd. for the first phase of a ferromanganese plant at Tamos near the Gulf port of Tampico. The first furnace with a 42 MVA transformer and a capacity of 50,000 tons per year is to be in operation late in 1975. Installation of additional furnaces is planned in stages to bring total capacity to 100,000 tons per year by 1977 and 200,000 tons per year by 1985.

South Africa, Republic of.—Johannesburg Consolidated Investment Co. Ltd. (JCI), African Metals Corp. Ltd. and Middleburg Steel and Alloys, Ltd., announced plans to raise ferrochromium capacity in the Republic to 500,000 tons per year. One specific project, utilizing the prereduced pellet process pioneered by Showa Denko K.K. of Japan was announced by JCI involving a 120,000-ton-per-year charge chromium plant in the Transvaal. The specific plant location had not been selected.

Union Carbide Corporation and General Mining and Finance Co. Ltd., announced a $38 million high-carbon ferrochromium project, located in eastern Transvaal, with a capacity of 120,000 tons per year and to be operational late in 1976. General Mining and Finance will provide ore supply, Union Carbide will design and operate the plant and the two companies will share marketing of the product.

Table 9.—Ferroalloys: World production by country[1] and furnace type

(Thousand short tons)

Country	1971	1972	1973 p
BLAST FURNACE[2]			
Europe:			
Belgium	r 144	136	126
Denmark	8	4	e 4
France	490	495	600
Germany, West[3]	373	347	405
Hungary	8	23	e 22
Italy	20	53	72
Poland	158	146	e 137
Portugal	8	9	e 11
U.S.S.R	1,110	r e 1,135	e 1,124
United Kingdom	170	166	190
Africa:			
South Africa, Republic of	72	76	e 76
Asia:			
Korea, Republic of[4]	16	18	40
ELECTRIC FURNACE[5]			
North America:			
Canada[2]	213	251	221
Mexico	74	85	e 85
United States[2]	2,331	2,527	2,520
South America:			
Argentina	31	47	e 47
Brazil	r 140	153	187
Chile	14	15	e 15
Europe:			
Austria	6	6	6
Bulgaria	47	49	e 50
Czechoslovakia	134	128	e 136
Finland	39	27	44
France	386	391	e 391
Germany, West	258	240	e 291
Hungary	11	11	e 11
Italy	192	188	191
Norway	r 724	704	793
Poland	147	193	e 173
Spain[6]	144	193	265
Sweden	260	277	e 247
Switzerland	25	e 23	e 23
Yugoslavia	128	144	170
Africa:			
South Africa, Republic of	420	460	e 460
Asia:			
India	r 240	217	e 182
Japan	2,083	1,921	2,243
Taiwan	8	8	9
Turkey e	10	10	10
Oceania:			
Australia[2,7]	79	r e 83	e 94
Total	r 10,721	10,959	11,671

e Estimate. p Preliminary. r Revised.

[1] In addition to the countries listed, the People's Republic of China and North Korea are known to produce ferroalloys but output of these materials are included in estimates for pig iron in the iron and steel chapter, therefore, they have been omitted here to avoid duplication. East Germany also is known to produce ferroalloys but it is not clear from source publications whether output has been included together with that of pig iron in the iron and steel chapter. Also, Colombia, Greece, Peru, Venezuela, and Southern Rhodesia may produce ferroalloys and output, if any, is also included with pig iron in the iron and steel chapter.

[2] Blast furnace ferroalloy production by Australia, Canada, and the United States included under electric furnace output; that of Czechoslovakia is included under pig iron.

[3] Blast furnace ferromanganese, ferrosilicon and spiegeleisen only; other blast furnace ferroalloys are included with pig iron production in the iron and steel chapter.

[4] Includes electric furnace ferroalloys if any are produced.

[5] In addition to the countries listed, the United Kingdom and the U.S.S.R. are known to have produced electric furnace ferroalloys and Romania may have produced some electric furnace ferroalloys, but output is not reported and no basis for estimation is available.

[6] May include small quantities of blast furnace ferroalloys, if any are produced.

[7] Year ended November 30 of year stated.

TECHNOLOGY

The stainless steel industry continued to adapt post-furnace refining techniques to finishing of stainless steel heats thereby reducing costs and increasing productivity. The argon-oxygen-decarburization (A.O.D.) and vacuum-oxygen-decarburization (V.O.D.) processes have furthered the trend towards greater utilization of high-carbon ferrochromium, minimizing the need for the low-carbon varieties. The ratio of high-carbon to low-carbon tonnage produced in 1973 approached 4 to 1, in contrast to the 3 to 1 ratio in 1972.

A modification of the A.O.D. process has been developed by Creusot-Loire and Uddeholm and applied by Uddeholm in the production of more than 5,000 tons of Extra Low Carbon 18% Cr-8% Ni stainless steel at the Degersfors plant of Uddeholm. Steam is basically substituted for argon during much of the treatment cycle. The sequence involves: (1) oxygen blowing to remove carbon until a critical temperature is reached; (2) oxygen and steam injection in varying ratios; and (3) argon and nitrogen injection to remove the hydrogen absorbed by the molten metal. Steam dissociates into oxygen and hydrogen and the hydrogen acts to reduce the partial pressure of carbon monoxide, continuing the carbon reduction with minimum oxidation of chromium. Dissociation of steam involving an endothermic reaction provides control of maximum temperatures and an overall recovery of over 98% of the chromium.

Inclusion shape control is essential to improve transverse ductility and raise toughness shelf energy values in high-strength low alloy steels for pipelines and automotive applications requiring high formability. Small additions of rare-earth metals, in conjunction with minimum sulfur levels and effective degassing prior to final deoxidation, are becoming increasingly necessary to meet the more stringent specifications. Rare-earth additions are made, generally during mold teeming, in the silicide form or as mischmetal.

The Japanese ferroalloy producer, Nippon Denko Co., Ltd., has been issued British Patent 1,317,523 covering a method of sintering chromite ore fines. A damp mixture of ore, coke, and forsterite or serpentine is sintered on a grate-type machine, cooled, and optionally broken. The low-melting magnesium silicate minerals provide a vitrified agglomerate with good strength. With power and capital investment costs increasing substantially, it is anticipated that prior treatment of ores, including partial reduction, will become more widespread as a means of increasing smelting furnace productivity and reducing unit power consumption.

Fluorspar

By H. B. Wood [1]

World supplies of fluorspar were ample during 1973. At the end of the year, major consuming countries such as the United States, Japan, and some European countries had adequate supplies. The 1973 output by the United States and the world showed no appreciable change from 1972. However, from the 1971 production (U.S. 272,000 tons and world 5,007,390 tons), which represented a 14-year peak, U.S. production in 1973 decreased about 9% and world production about 1%.

In 1973 most of the large producing companies were not operating at full capacity. Consequently, any emergency or uniform price increase could readily increase production. Some of the companies that discovered large deposits during the 1968–72 boom exploration years decided to continue development operations and bring these mines into production in anticipation of an increase in world consumption.

Overall, U.S. fluorspar consumption has not shown any significant increase since 1969. During this past 5-year period consumption of acid-grade fluorspar by hydrofluoric acid manufacturers decreased 8% to 664,000 tons, consumption of metallurgical-grade fluorspar by the iron and steel industry increased 11% to 649,400 tons, and ceramic-grade fluorspar consumption by the glass and ceramic industries decreased 30% to 18,000 tons.

The trend in consumption of fluorspar in primary aluminum and magnesium production is more difficult to determine. The direct use, shown in table 5, is only a small percentage of the total. Most of the fluorspar used by the aluminum industry is first converted to hydrofluoric acid and then to aluminum fluoride and sodium aluminum fluoride (synthetic cryolite) for use as an electroflux in the aluminum potlines melt to produce aluminum.

Total fluorspar demand by the aluminum industry decreased during 1972 and increased slightly in 1973, as aluminum companies reduced fluorspar consumption per ton of aluminum. Pressure from the Environmental Protection Agency (EPA) and economic changes instituted by the companies helped speed up recycling programs. The major EPA required improvements will probably be completed by the end of 1974.

The 1973, reported consumption of 1,351,700 tons, almost equaled the 1972 reported consumption of 1,352,100 tons. The U.S. output provided 18% of reported U.S. consumption and 17% of apparent consumption. The apparent consumption, which includes U.S. shipments, plus imports, plus a decrease in consumers' stockpiles, minus exports, equaled 1,508,800 tons and exceeded reported consumption by about 157,100 tons.

U.S. shipments of finished fluorspar were about the same as in 1972, totaling about 248,600 tons. Production was almost equally divided between acid-grade fluorspar (acid-spar) and metallurgical-grade fluorspar (met-spar). Producers' and consumers' stockpiles combined were reduced over 56,800 tons, indicating that both producers and consumers realized the availability of adequate supplies.

During the year, eight mines and four flotation concentrating plants were closed down, and one flotation plant in Illinois was placed on a part-time operating basis. These closings could ultimately reduce U.S. output by 80,000 to 90,000 tons in 1974, if production from new or reopened mines or increased production from currently operating mines does not materialize.

[1] Geologist, Division of Nonmetallic Minerals—Mineral Supply.

The available supply of fluosilicic acid, that was converted to aluminum fluoride and sodium aluminum fluoride, continued to increase slightly. Construction of new phosphoric acid plants with built in circuits to recover $H_2S_6F_6$ probably will increase the supply in the near future.

Table 1.—Salient fluorspar statistics

	1969	1970	1971	1972	1973
United States:					
Production:					
Mine production ---------short tons--	533,030	627,212	815,046	710,668	561,149
Material beneficiated ----------do----	520,084	698,232	758,169	771,411	663,361
Material recovered ------------do----	160,000	252,128	247,250	245,047	232,891
Finished (shipments) ---------do----	182,567	269,221	272,071	250,347	248,601
Value -----------------thousands--	$8,411	$13,923	$17,263	$17,315	$17,337
Exports ---------------------short tons--	3,605	14,952	12,491	2,764	2,428
Value ---------------------thousands--	$213	$1,145	$525	$184	$171
Imports for consumption ----short tons--	1,149,546	1,092,318	1,072,405	1,181,533	1,212,347
Value ---------------------thousands--	$32,818	$32,758	$34,530	$47,851	$52,620
Consumption (reported) -----short tons--	1,356,624	1,372,404	1,344,742	1,352,149	1,351,705
Stocks Dec. 31:					
Domestic mines:					
Crude --------------------do----	82,177	51,471	165,610	111,565	57,901
Finished ------------------do----	9,751	12,370	28,259	15,294	8,675
Consumer --------------------do----	290,470	419,746	436,759	377,942	327,703
World: Production -----------------do----	4,285,010	4,620,469	r 5,013,290	r 4,974,333	4,927,849

r Revised.

Legislation and Government Programs.—On April 16, 1973, the Office of Management and Budget submitted an "omnibus bill" (OMB No. 5) to the U.S. Congress which proposed disposing of many of the minerals in government stockpiles. Under section 2 of the bill, 890,000 tons of acid-grade fluorspar and 252,800 tons of metallurgical-grade fluorspar, now in government stock, were recommended for sale by the General Services Administration (GSA).

On May 14, 1973, GSA held a meeting with fluorspar producers and consumers in Washington, D.C., and presented a plan to dispose of 1,142,800 tons of fluorspar over a 2-year period. Representatives of the fluorspar industry objected to the proposed plan. Thereupon, GSA agreed to take into consideration industry recommendations for selling the material over a longer period of time (10 to 15 years) and to present a revised disposal plan to industry before implementation. As of the yearend, no action had been taken on OMB No. 5.

Table 2.—Shipments of finished fluorspar, by State

State	1972			1973		
	Quantity (short tons)	Value		Quantity (short tons)	Value	
		Total (thousands)	Average per ton		Total (thousands)	Average per ton
Illinois -------------------	132,405	$9,961	$75.23	160,305	$11,871	$74.05
Utah ---------------------	2,977	84	28.22	4,778	144	30.14
Other States[1] -----------	114,965	7,270	63.24	83,518	5,322	63.72
Total and average -	250,347	17,315	69.16	248,601	17,337	69.74

[1] New Mexico, 1972; Arizona, Colorado, Kentucky, Nevada, and Texas, 1972–73.

Table 3.—Shipments and mine stocks of finished fluorspar by grade, in the United States

Grade	1972				1973			
	Quantity (short tons)	Value (thousands)	Average per ton	Stocks[1] (short tons)	Quantity (short tons)	Value (thousands)	Average per ton	Stocks[1] (short tons)
Acid ---------------	133,348	$8,443	$63.32	9,867	116,104	$7,402	$63.75	3,619
Metallurgical ------	116,999	8,872	75.83	5,427	132,497	9,935	74.98	5,056
Total and average ----	250,347	17,315	69.16	15,294	248,601	17,337	69.74	8,675

[1] Mine stocks as of Dec. 31.

Table 4.—Fluorspar shipped from mines in the United States, by grade and use

Grade and use	1972 Quantity: Short tons	1972 Quantity: Percent of total	1972 Value: Total (thousands)	1972 Value: Average per ton	1973 Quantity: Short tons	1973 Quantity: Percent of total	1973 Value: Total (thousands)	1973 Value: Average per ton
Ground and flotation concentrates:								
Hydrofluoric acid	111,786	56.7	$8,385	$75.01	99,145	53.2	$7,300	$73.63
Glass	22,375	11.4	1,751	78.26	23,505	12.6	1,854	78.88
Ceramic and enamel	10,625	5.4	491	46.21	10,570	5.7	599	56.67
Nonferrous	715	.4	57	79.72	--	--	--	--
Ferrous [1]	49,619	25.2	3,638	73.32	50,662	27.1	3,825	75.50
Miscellaneous	1,877	.9	151	80.45	2,625	1.4	212	80.76
Total and average	196,997	100.0	14,473	73.47	186,507	100.0	13,790	73.94
Fluxing gravel and foundry lumps:								
Ferrous	52,672	98.7	2,793	53.03	59,874	96.4	3,367	56.23
Miscellaneous	678	1.3	49	72.27	2,220	3.6	180	81.08
Total and average	53,350	100.0	2,842	53.27	62,094	100.0	3,547	57.12

[1] Includes exports.

DOMESTIC PRODUCTION

U.S. shipments of finished fluorspar totaled 248,601 tons, of which 47% was acid grade and 53% metallurgical grade. Although overall output showed little change from 1972, acid-spar production decreased 13% whereas met-spar increased 13%. Mine stocks of finished fluorspar were down 6,600 tons, leaving less than 8,700 tons in stock at yearend. Mine production, material beneficiated, and material recovered were all down appreciably.

The fluorspar industry started to slow down production before the year was half over. At the start of 1973, there were 23 mines and 7 froth flotation plants in operation; during the year 8 mines and 4 flotation plants closed down. These included the Pennwalt Corp. Calvert City Chemical Co. plant in Kentucky, the Ozark-Mahoning Co. Cowdrey (Northgate) plant in Colorado, the Allied Chemical Corp. Boulder City plant in Colorado, and the Tonto Mining and Milling Co., Inc. Tonto Basin (Pumpkin Center) plant in Arizona. The Minerva Oil Co. flotation unit of the Crystal mill in Illinois was placed on an intermittent operating schedule. Three mines were closed down in Kentucky, three in Colorado and two in Arizona. Although Roberts Mining Co. shipped ore from its stockpiles near Darby, Mont., their open pit mine has not operated since 1971. Cumulatively, over 140,000 tons of flotation milling capacity was lost; but during the past 2 years the output from these plants has only averaged about 90,000 tons annually, mainly because the mines could not supply the mills.

On the favorable side of the output picture, the Knight mine and heavy-media plant went onstream in Illinois, the Lafayette mine was reactivated in Kentucky, and Cerro Spar Corp. near Salem, Ky. continued to develop the Babb-Barnes mine and to build a flotation plant with a potential output capacity of 60,000 tons annually. No new mine openings were reported from the West. Reactivation of Minerva's Crystal mill and new production from the Babb-Barnes mine and others may add another 40,000 tons by the end of 1974.

In Illinois, exploration and development drilling continued on the Hicks Dome property in Hardin County. Some exploration and reevaluation studies were performed. Minerva Oil is now a steady producer of barite, for use in drilling muds and paint pigments, as a byproduct from the Minerva No. 1 mine. Income from this byproduct barite, allows a reduction in mill input grade to about 28% CaF_2. In Kentucky, Cerro Spar Corp., continued developing the Babb-Barnes mine while building the new flotation plant. Also in Kentucky near Salem, Minerva Oil Co. reactivated the old Wheatcroft shaft at the Lafayette mine, and Don Grahm, an independent operator, started trucking crude ore from the Midway mine to the Babb-Barnes mill. In Tennessee, exploration drilling by U.S. Borax and Chemical Corp.

and Amoco Minerals Co. continued on a fluorspar prospect in the Sweetwater barite district near Sweetwater in Monroe County.

In Colorado extensive prospecting, drifting, and drilling were performed on numerous prospects, but no firm production announcements were made on new prospects. The Industrial Chemicals Division of Allied Chemical Corp. sealed the shafts of the Burlington and Yellow Bird mines near Jamestown and placed the Boulder flotation plant on standby. In Salida, Colo., Allied continued exploration drilling on the westerly vein of the old Colorado-American mine in the Browns Canyon fluorspar belt. Also, Kalium Chemical Co. in 1972 and 1973 performed exploration drilling on its claims which cover the northern extension of the Browns Canyon fluorite fault-contact zone. Ozark-Mahoning Co. in the Northgate Area at the end of 1973 placed its three fluorspar mines and the Cowdrey flotation and briquetting plant on a standby basis. In the Jamestown Area Inexco Inc. continued active exploration drifting at its Escanaba mine. In Idaho NL Industries, Inc. completed exploration drilling, drifting, and ore testing on the Bayhorse fluorspar mine near Challis and was completing feasibility and environmental impact studies. In Montana Roberts Mining Co. continued to ship met-spar from its stockpile.

In Nevada J. Irving Crowell continued to produce met-spar from the Daisy mine and ship ore to Monolith Cement Co. at Tehachapi, Calif., and to Geneva Works of U.S. Steel Co. near Salt Lake City, Utah.

In New Mexico at least four companies were actively drilling and increasing the reserves at some prospects, but no production announcements were made. Mining and Milling Co. of America continued construction of its flotation plant located 32 miles south of Hachita, on the east side of the Hachet Mountains. Reportedly, both their heavy-media and flotation plants were onstream at the end of the year. The most extensive exploration was performed by Allied Chemical, on the Lyda-K. prospect, located southeast of Truth or Consequences, and by the joint venture of Midwest Oil and Perry-Knox and Kaufman on the Salado prospect, located southwest of Truth or Consequences.

Near Rome in Malheur County, Oregon, Aluminum Company of America (Alcoa) did some more exploration drilling and sampling, mainly for assessment purposes, on its Crooked Creek claims.

In Texas exploration drilling was performed on a fluorspar prospect in the Eagle Mountains near Van Horn in Hudspeth County. In the Christmas Mountains north of the Big Bend country, D & F Minerals Co. continued operating the La Paisano mine and trucking subgrade met-spar to Marathon for screening and then transhipment by Bailey Fluorspar Co. to steel companies. Bailey Fluorspar Co. also continued to receive ore from its mine (Mal Abrigo) in Coahuila, Mexico, and from other privately owned mines in Chihuahua, and Durango, Mexico. The ore is screened and sized at Marathon before transhipment.

In Utah, Willden Fluorspar Co., Spor Brothers, and U.S. Energy Corp. continued to produce met-spar. No new significant activity was reported from Alaska or Arizona, where prospecting and drilling have been active in recent years.

During 1973 there were seven fluorspar briqueting plants known to be operating in the United States. In addition there was one plant known to be making a 2 by 8 inch fluorspar brick for use as a furnace liner. Concentrate fines containing 93% CaF_2 were used to make the bricks, which act as a flux and metal purifier. There were also two clay brick plants which added 100 to 200 pounds of 95% CaF_2 concentrate to every ton of clay brick kilned.

During 1973 approximately 280,000 tons of fluorspar briquets. ½- to 1½-inch size, were produced by the seven plants and sold to steel companies. In making briquets, some companies used only acid-spar concentrate and diluted it with molasses binder, lime, and a large portion of limestone to about 70% effective CaF_2. Other companies mixed together everything from low grade met-spar fines to gravel and acid-grade concentrate. The different mixes and grades were prepared to conform with customer specifications. Most of the briquetting plants were built during the 1968-70 period when prices were rising rapidly. There are three plants at Brownsville, Tex., and one each at Dearborn, Mich., Pittsburgh, Pa., Rosiclare, Ill., and Cowdrey, Colo. The Cowdrey, Colo., plant, owned by Ozark-Mahoning, was closed down at the end of 1973. The two clay-fluorspar brick plants are at East Canton and Nelsonville, Ohio. The fluorspar brick plant is in Cleveland, Ohio.

In February 1973 at the AIME Society of Mining Engineers meeting in Chicago, Ill., a special session was held on a world review of fluorspar. Five excellent papers were presented discussing U.S. and world reserves and production capabilities and uses in the chemical and aluminum industries.

In April 1973 at the Annual Forum on the Geology of Industrial Minerals held at Paducah, Kentucky, a symposium was held on the geology of fluorspar. Ten papers covering various geological aspects of both U.S. and foreign fluorspar deposits were presented. Proceedings of the forum were published by the Kentucky Geological Survey.

Reserves.—U.S. fluorspar reserves totaled about 25 million tons of ore containing about 35% CaF_2 or 4,100,000 tons of fluorine. Also, 28 million tons of submarginal material analyzing about 17% CaF_2, have been developed at the Lost River Mining Co. claims on Seward Peninsula, Alaska. Near Rome in southeastern Oregon there is another 12 million tons of tufaceous siltstone and claystone containing 8% to 10% CaF_2 that may be classified as a resource. U.S. reserves are mainly in Illinois, Kentucky, Tennessee, Colorado, Montana, Idaho, Texas, Nevada, Utah, Arizona, and New Mexico. These reserves occur in small isolated ore bodies or clusters of ore bodies, and as irregularly shaped pods or veins within localized mining districts. The mined rock generally contains from 25% to 70% CaF_2. Most of the deposits are of less than 500,000 tons, but there are a few larger low-grade deposits that may become commercially attractive if they can be mined by open pit methods and if the rock is amenable to beneficiation.

Table 5.—U.S. consumption of fluorspar by end use and by grade in 1973
(Short tons)

End use or product	Containing more than 97% calcium fluoride	Containing not more than 97% calcium fluoride	Total
Hydrofluoric acid	663,940	--	663,940
Glass and fiberglass	6,716	3,918	10,634
Enamel	(1)	7,293	7,293
Welding rod coatings	528	(1)	528
Primary aluminum	1,169	--	1,169
Primary magnesium	672	--	672
Other nonferrous metals	--	516	516
Iron and steel castings	288	35,139	35,427
Open hearth furnaces	--	88,401	88,401
Basic oxygen furnaces	--	411,556	411,556
Electric furnaces	2,850	111,215	114,065
Other uses or products [2]	491	17,013	17,504
Total	676,654	675,051	1,351,705
Stocks Dec. 31	266,421	61,282	327,703

[1] Included with "Other uses or products."
[2] Includes fluorspar used to make ferroalloys and other furnace products.

Table 6.—Fluorspar (domestic and foreign) consumed in the United States, by State
(Short tons)

State	1973
Alabama, Kentucky, Tennessee	93,617
Arizona, Colorado, Utah	23,488
Arkansas, Kansas, Louisiana, Missouri	166,906
California	42,065
Connecticut, Massachusetts, New York, Rhode Island	39,719
Illinois	86,715
Indiana	77,542
Iowa, Minnesota, Nebraska, Wisconsin	3,711
Michigan	71,286
New Jersey	86,175
Ohio	153,133
Oregon, Washington	1,095
Pennsylvania	168,154
Texas	258,212
West Virginia	49,761
Other States [1]	30,126
Total	1,351,705

[1] Includes Florida, Georgia, Maryland, North Carolina, Virginia, Delaware, Mississippi, and Oklahoma.

CONSUMPTION AND USES

In the United States, fluorspar of varied specifications was used by the steel, glass, ceramic, brick, and cement industries. Fluorine derived from fluorspar and manufactured into hydrofluoric acid (HF) is essential to the chemical, aluminum, airplane, medicinal, oil, and nuclear reactor industries and for fluoridating drinking water. Consumption trends for fluorspar depend directly on the growth of the above industries. The domestic steel industry consumed about 45% of the total fluorspar, the chemical industry about 33%, the aluminum and nonferrous industry about 19%, and other industries about 3%.

The share of total consumption used by the iron and steel industry increased from 43% in 1969 to 45% in 1973. Conversely the share of total consumption used to manufacture hydrofluoric acid decreased from 53% to 49%. During this same 1969–73 period, reported consumption of all grades of fluorspar has remained steady at about 1,355,000 tons annually.

Demand by miscellaneous consumers has broadened considerably in the past few years, although actual consumption remained small. Major uses in this category include catalysts in the oil industry, additives for calcining in the cement industry, storage of radioactive uranium as UF_4 for the nuclear reactor industry, and the manufacture of permanent self-sealing lubricants impregnated in movable parts.

Production of fluorocarbon 11 and 12, which is commonly used in home and automobile refrigeration, decreased notably during the energy shortage in the second half of 1973 when air conditioners were slowed down or shutoff. Union Carbide Corp. enlarged the capacity of its plant at Institute, W. Va., by 30% to about 200 million pounds annually of fluorocarbon 11 and 12. In 1973, Buss Ltd. of Basel, Switzerland was awarded a contract by Companhia Nitro Quimica Brasileira to build three plants a 8,500-ton-per-year hydrofluoric acid plant, a 6,000-ton-per-year aluminum fluoride plant, and a 6,000-ton-per-year cryolite (sodium aluminum fluoride) plant to be located at São Miguel Paulista, Brazil. The plants are due for completion by yearend 1975.[2]

Finally in 1973 the State of Georgia General Assembly passed into law a bill requiring fluoridation of all public drinking water in incorporated communities, thereby eliminating one of the last strongholds against water fluoridation. No action is anticipated in 1973 and 1974, since the State must pay for all equipment and installation and no funds have as yet been provided. Furthermore, any local government can remove itself from the provision by a referendum vote.

STOCKS

U.S. producers reported a 43% decrease in their stock of finished fluorspar from 15,294 tons in 1972 to 8,675 tons in 1973, an alltime low since complete records were started in 1940. U.S. consumers stocks decreased 13% (50,239 tons) in 1973, which indicated that consumers were not worried about an adequate supply. Excess stocks of finished fluorspar were reported in the producing countries of Mexico, Thailand, Kenya, and the Republic of South Africa.

PRICES

Prices of finished fluorspar ready for use varied according to specifications and location. The Engineering and Mining Journal (E/MJ) notes that acid-spar prices were mostly in the \$78.50- to \$87-per-short-ton range; same as in 1972. However, some spot sales were reported at \$70 per ton and others at \$87.50 per ton. Domestic 70% CaF_2 met-spar pellet prices were standardized at \$65.50 per ton, but 88% CaF_2 pellets were priced at \$76.50 per ton. Most briquets varied considerably in price, since their effective CaF_2 content ranged from 65% to 94% CaF_2. The gravel met-spar price reported in E/MJ at the Mexican border was \$48.50. However, a quality-grade gravel met-spar of 70% to 75% effective CaF_2, as produced by the larger

[2] European Chemical News. Business World. Jan. 25, 1974, p. 18.

companies, was reported during 1972 and 1973 to be $60 per ton, f.o.b., c.i.f. included, midstream at the Mexican border.

Drastic fluctuations in European prices were caused by the changing value of the U.S. dollar and by sharp increases in ocean freight costs, which occurred during the last quarter of 1973. Most of the freight increase was absorbed by the European producer, but some was absorbed by the U.S. buyer. Prices in Europe temporarily soared to $97 per ton for acid-spar, f.o.b. U.S. port.

Prices at South African ports ranged from $37 to $40 per ton for acid-spar during 1972, but none was exported to the U.S. during 1973. Met-spar prices in Thailand held at $32 to $35 per metric ton and acid-spar prices were quoted at $65 per metric ton, f.o.b. Bangkok.

Although price rises in 1973 were restrained because of the plentiful supply in Thailand, Mexico, the Republic of South Africa, and some European countries, the cost of producing fluorspar throughout the world has been going up.

Table 7.—U.S. prices of fluorspar

	1972	1973
Domestic, f.o.b. Illinois-Kentucky:		
Pellets, (briquets) 70% effective CaF_2	$68.50	$65.50
Pellets, (briquets) 88% effective CaF_2	76.50	76.50
Ceramic-grade, 88% to 97% CaF_2	$76.50–82.00	$76.50–87.00
Acid-grade concentrates, dry, more than 97% CaF_2:		
Carloads	78.50–87.00	78.50–87.00
Less than carloads	78.50–87.00	78.50–87.00
Bags, extra	6.00	6.00
European: f.o.b. Wilmington/Philadelphia:		
Acid-grade, duty paid, dry basis, 97% CaF_2	97.50	97.50
Acid-grade, duty paid, wet filter cake 97% CaF_2	95.00–97.00	95.00–97.00
Mexican:		
Metallurgical-grade, 70% effective CaF_2:		
Border, f.o.b. railroad cars	48.50	48.50
Tampico, Mex., f.o.b. vessel	50.00	50.00
Acid-grade, more than 97%: Eagle Pass, Tex., bulk	62.00–67.00	60.00–62.00

Source: As listed in the December issues of Engineering and Mining Journal, 1972 and 1973.

FOREIGN TRADE

U.S. imports for consumption totaled 1,212,347 tons or about 90% of the U.S. total reported consumption of 1,351,705 tons. On the other hand, U.S. imports totaled only 80% of the apparent consumption, which is a more realistic percentage. The downward trend in U.S. exports, which started in 1970 continued through 1973. Fluorspar exports in 1973 decreased 12% below the 1972 tonnage of 2,764 tons. About 87% of the total exports moved across the northern border into Canada. U.S. foreign trade, as in the past, continued to be with free world countries.

Table 8.—U.S. exports of fluorspar

Year and country	Quantity (short tons)	Value
1970	14,952	$1,144,861
1971	12,491	525,489
1972	2,764	183,620
1973:		
Brazil	110	10,522
Canada	2,124	140,299
South Africa, Republic of	146	15,659
Venezuela	45	4,067
Other	3	708
Total [1]	2,428	171,255

[1] Adjusted by the Bureau of Mines, Division of Nonmetallic Minerals—Mineral Supply.

Table 9.—U.S. imports for consumption of fluorspar, by country and customs district

Country and customs district	1972 Quantity (short tons)	1972 Value (thousands)	1973 Quantity (short tons)	1973 Value (thousands)
CONTAINING MORE THAN 97% CALCIUM FLUORIDE				
Brazil: New Orleans	--	--	10,705	$569
Germany, West:				
Detroit	--	--	4,925	244
Philadelphia	5,202	$295	--	--
Total	5,202	295	4,925	244
Guatemala: El Paso	--	--	90	5
Italy:				
Cleveland	10,127	888	--	--
Detroit	7,726	429	--	--
Galveston	42,176	2,453	52,140	3,198
New Orleans	14,212	782	6,247	386
Total	74,241	4,552	58,387	3,584
Mexico:				
Detroit	--	--	1,014	32
El Paso	63,925	1,635	90,474	3,638
Houston	758	31	148	8
Laredo	321,542	13,283	262,188	11,318
Los Angeles	--	--	78	5
New Orleans	42,788	2,543	48,218	3,028
Nogales	23,423	839	703	25
Philadelphia	18,234	1,142	--	--
San Diego	234	13	312	14
Total	470,904	19,486	403,135	18,068
Mozambique: New Orleans	5,256	247	7,578	371
Portuguese West Africa, n.e.s.: New Orleans	--	--	9,932	615
South Africa, Republic of:				
Baltimore	1,069	41	--	--
Galveston	5,032	199	--	--
Philadelphia	8,318	305	--	--
Total	14,419	545	--	--
Spain:				
Cleveland	25,701	1,770	28,314	1,683
Detroit	31,433	1,950	13,899	934
Galveston	3,373	232	2,832	198
New Orleans	4,435	279	--	--
Philadelphia	69,898	4,702	114,780	7,031
Total	134,840	8,933	159,825	9,846
Switzerland: Philadelphia	--	--	5,804	348
Tunisia:				
Detroit	--	--	5,430	250
New Orleans	6,002	367	19,610	1,095
Total	6,002	367	25,040	1,345
United Kingdom:				
Cleveland	--	--	6,984	437
New Orleans	--	--	13,487	797
Total	--	--	20,471	1,234
Grand total	710,864	34,425	705,892	36,229

See footnotes at end of table.

Table 9.—U.S. imports for consumption of fluorspar, by country and customs district—Continued

Country and custom district	1972 Quantity (short tons)	1972 Value (thousands)	1973 Quantity (short tons)	1973 Value (thousands)
CONTAINING NOT MORE THAN 97% CALCIUM FLUORIDE				
Canada: Portland, Me	--	--	24	(1)
Colombia: Philadelphia	2,642	$97	--	--
Guatemala: El Paso	--	--	348	$7
Mexico:				
Baltimore	11,657	494	19,141	768
Buffalo	18,758	522	29,149	1,246
Chicago	1,430	69	--	--
Cleveland	27,461	1,393	29,831	1,520
Detroit	16,643	781	17,355	752
El Paso	30,501	718	29,793	866
Houston	158	6	--	--
Laredo	300,692	6,825	295,344	7,461
New Orleans	25,032	1,093	49,366	2,304
Nogales	214	7	--	--
Philadelphia	20,558	866	18,847	792
St. Albans	227	8	--	--
Total	453,331	12,782	488,826	15,709
South Africa, Republic of:				
Buffalo	5,311	220	--	--
New Orleans	9,385	327	--	--
Total	14,696	547	--	--
Spain:				
Buffalo	--	--	6,605	264
Detroit	--	--	5,175	164
New Orleans	--	--	5,477	247
Total	--	--	17,257	675
Grand total	470,669	13,426	506,455	16,391

[1] Less than ½ unit.

Table 10.—U.S. imports for consumption of 70% hydrofluoric acid

Country	1971 Quantity (short tons)	1971 Value	1972 Quantity (short tons)	1972 Value	1973 Quantity (short tons)	1973 Value
Canada	19,601	$5,901,369	12,946	$4,510,698	30,196	$9,295,461
Germany, West	(1)	574	(1)	692	(1)	897
Japan	50	8,730	--	--	--	--
Mexico	1,698	586,704	1,225	404,203	1,467	527,110
United Kingdom	(1)	888	--	--	--	--
Total	21,349	6,498,265	14,171	4,915,593	31,663	9,823,468

[1] Less than ½ unit.

WORLD REVIEW

Canada.—In 1973, Canada produced 151,000 tons of fluorspar, almost all acid-spar. This was 16% lower than in 1972, and the reason for the decline was a 1-month labor strike. Less than 1% of Canada's production was met-spar, which was used locally at a Newfoundland steel plant. The following tabulation shows Canada's imports of all grades of fluorspar during the first 9 months of 1973, at the Canadian port of entry.

Country	Quantity (short tons)	Total value	Average per ton
Mexico	69,776	$3,527,000	$50.55
United Kingdom	26,071	1,070,000	41.04
Spain	18,595	516,000	27.75
United States	3,218	216,000	67.12
Total and average	117,660	5,329,000	45.29

Imports of fluorspar from Mexico, the United Kingdom, and the United States accelerated in the last quarter of the year. Based on Canada's imports in the first 11 months of 1973, a total import of 161,470 tons is estimated for the year. This would be a 55% increase over the tonnage imported during 1972. Most of the increase was in met-spar.

All of the fluorspar produced in Canada was mined by one company, Aluminum Company of Canada Ltd. (Alcan), from three mines in the Burin Peninsula of Newfoundland. Alcan started in 1973 to develop a new mine near St. Lawrence, and work continued throughout the year.

During 1973, a new evaluation and feasibility study was underway on the Rock Candy mine near Grand Forks, British Columbia, which is owned by Cominco Ltd., and leased by Alcan. Fluorspar had been produced from this mine during the 1918 to 1942 period, and large reserves of 60% CaF_2 were reported as still remaining.

The Birch Island fluorspar prospect of Consolidated Rexspar Minerals & Chemicals Ltd., located about 60 miles north of Kamloops, British Columbia, was subjected to additional exploration drilling, geochemical soil sampling, and feasibility studies during 1972 and 1973. About 1 million tons of proven and 500,000 tons of possible ore containing an average of 29% CaF_2 were delineated. According to Denison Mines Ltd., which has a 44% interest in Consolidated Rexspar, activity was temporarily suspended so as to evaluate preliminary findings.[3] Exploration activity in the Madoc district of Southern Ontario has also been temporarily suspended by some of the companies that were active during 1972.

Huntington Fluorspar Mines Ltd. continued to make fluorspar bricks at its plant near North Brook, Ontario. Imported met-spar was used to make the bricks for iron foundries.

[3] The Northern Miner. Rexspar's Fluorite interests Japanese. V. 58, No. 47, Feb. 8, 1973, p. 21.

Table 11.—Fluorspar: World production by country

(Short tons)

Country [1] and grade [2]	1971	1972	1973 [p]
North America:			
Canada (shipments)	[e] 80,000	179,700	151,000
Mexico	1,301,779	1,149,039	1,196,992
United States (shipments):			
Acid grade	106,263	133,348	116,104
Metallurgical grade	165,808	116,999	132,497
Total	272,071	250,347	248,601
South America:			
Argentina	[r] 79,734	66,334	[e] 66,000
Brazil	[r] [e] 50,000	78,235	[e] 71,000
Europe:			
Czechoslovakia [e]	100,000	100,000	100,000
France: [3]			
Acid grade	191,461	208,978	[e] 215,000
Metallurgical grade	79,331	[e] 111,022	[e] 115,000
Total	270,792	[r] [e] 320,000	[e] 330,000
Germany, East [e]	90,000	90,000	90,000
Germany, West (marketable)	[r] 93,351	102,154	95,828
Italy	[r] 325,833	305,244	259,630
Romania [e]	17,000	17,000	17,000
Spain:			
Acid grade [4]	315,272	344,676	[e] 320,000
Metallurgical grade [5]	54,819	99,614	[e] 110,000
Total	[r] 370,091	444,290	[e] 430,000
Sweden:			
Ceramic grade [e]	--	550	3,300
Metallurgical grade [e]	--	450	2,700
Total [e]	--	1,000	6,000
U.S.S.R.[e]	460,000	470,000	490,000
United Kingdom: [6]			
Acid grade	158,700	155,400	[e] 155,000
Metallurgical grade	69,400	62,800	[e] 65,000
Ungraded	4,400	1,100	--
Total	[r] 232,500	219,300	[e] 220,000

See footnotes at end of table.

Table 11.—Fluorspar: World production by country—Continued

Country [1] and grade [2]	1971	1972	1973 p
Africa:			
Egypt, Arab Republic of	710	990	e 1,000
Kenya	7,232	11,527	7 29,468
Mozambique	9,059	1,575	--
Rhodesia, Southern e	165	165	165
South Africa, Republic of:			
Acid grade	155,450	157,502	204,262
Ceramic grade	15,265	19,688	4,933
Metallurgical grade	92,782	55,184	22,647
Total	263,497	232,374	231,842
Tunisia:			
Acid grade	31,311	44,696	47,735
Metallurgical grade	5,020	6,046	3,633
Total	36,331	50,742	51,368
Asia:			
Burma	8 222	248	e 220
China, People's Republic of e	280,000	280,000	280,000
India	3,425	3,418	3,097
Japan	14,022	9,147	e 8,800
Korea, North e	33,000	33,000	33,000
Korea, Republic of	r 56,272	30,861	24,423
Mongolia e	88,000	r 110,000	110,000
Pakistan	5,258	2,627	1,758
Thailand (high grade) [9]	r 471,235	412,915	377,079
Turkey	1,200	e 1,200	2,168
Oceania: Australia	511	901	e 1,410
Grand total	r 5,013,290	4,974,333	4,927,849

e Estimate. p Preliminary. r Revised.

[1] In addition to the countries listed, Bulgaria and Morocco are also believed to have produced fluorspar, but production is not reported and available information is inadequate to make reliable estimates of output levels.

[2] In those cases where official production statistics of the respective countries are reported subdivided by grade (acid, ceramic, and/or metallurgical), this breakdown has been reported. No attempt has been made to separate by grade the output of countries which have not officially reported their production on this basis, although some information on such a breakdown may be available from unofficial sources.

[3] Totals reported represent marketable product, a combination of directly salable mine product and concentrate produced from ores that are not usable without beneficiation. In 1971 (the only year for which full detail is available), direct shipping ore totaled 129,747 short tons, while concentrates produced totaled 141,045 short tons, these concentrates being produced from 456,622 short tons of crude ore. The latter figure includes both newly mined domestic ore and additional material of unspecified origin, with actual 1971 mine output of ore for concentration totaling only 379,742 short tons. Total actual ore output (direct shipping ore plus ore for concentration) was 509,490 short tons in 1971; comparable total ore output figures for later years are: 1972—602,168 short tons (provisional) and 1973—610,000 short tons (estimated). The distribution of total salable product into acid-grade and metallurgical-grade is based on information on chemical-grade output reported in Annales des Mines, August-September 1973, p. 67.

[4] Data presented includes recorded production of salable acid-grade fluorspar from both fluorspar mines and lead-zinc-fluorspar mines plus an estimate for the production of salable acid-grade fluorspar obtained by beneficiating a portion of total reported salable metallurgical-grade fluorspar output. Total reported production of acid-grade fluorspar was as follows in short tons: 1971—270,697; 1972—279,843; 1973—263,145. Estimated production of acid-grade fluorspar from beneficiation of metallurgical-grade fluorspar was as follows in short tons (with quantity of metallurgical grade fluorspar reported as being processed in this manner given in parentheses following estimated acid-grade output): 1971—44,575 (111,438); 1972—64,832 (162,080); 1973 (all estimated)—54,000 (136,000).

[5] Data presented are the difference resulting from the subtraction of that quantity of metallurgical-grade fluorspar reportedly consumed for the production of acid-grade fluorspar (see footnote 4) from the total reported metallurgical-grade fluorspar output.

[6] Includes materials recovered from lead-zinc mine dumps.

[7] Sales only.

[8] Data are for year ending June 30 of that stated.

[9] Excludes so-called low grade ore (1971 quantity not available, 1972—22,575 short tons and 1973—61,646 short tons) which apparently was not used for traditional fluorspar uses.

Table 12.—Fluorspar: World trade[1] by source and destination in 1972

(Short tons)

Sources	Australia[2]	Austria	Belgium-Luxembourg	Canada	Germany, West	India	Italy	Japan	Netherlands
	Destinations								
Argentina	--	--	--	--	--	--	--	220	--
Brazil	--	--	--	--	--	--	--	5,693	--
China, People's Republic of	--	--	595	--	--	--	--	118,013	--
France	--	3,333	7,765	--	--	--	18,306	839	132
Germany, East	--	6,550	1,918	--	--	--	--	--	--
Germany, West	--	2,562	3,225	--	--	--	1,132	--	1,709
Italy	--	2,187	--	--	12,488	5,730	--	--	2,150
Japan	--	--	--	--	--	--	--	--	--
Korea, North	--	--	--	--	--	--	--	3,450	--
Korea, Republic of	--	--	--	--	--	--	--	30,425	--
Mexico	--	--	--	51,074	--	--	11,213	4,504	--
Mongolia	--	--	--	--	--	--	--	--	--
Mozambique[3]	--	--	--	--	1,058	--	--	1,799	--
South Africa, Republic of	3,602	90	--	--	1,924	--	9,946	115,497	--
Spain	--	--	--	7,398	49,503	--	--	--	--
Thailand	9,925	--	--	--	--	--	--	252,444	--
Tunisia	--	--	--	--	--	294	24,057	--	--
U.S.S.R	--	--	--	--	--	--	--	2,500	--
United Kingdom	3,325	--	88	10,566	--	97	10,182	4,751	--
United States	--	--	--	2,871	--	--	791	--	--
Other and/or unspecified	750	272	2	--	109,691	[4] 4,936	3,378	948	22,902
Total	17,602	14,994	13,593	71,909	[5] 174,664	11,057	79,005	541,083	26,893

Sources	Norway	Poland	Sweden	U.S.S.R.	United States	Other[6]	Total receipts	Total recorded exports
	Destinations—Continued							
Argentina	--	--	--	--	--	--	220	NA
Brazil	--	--	--	--	--	--	5,693	[7] 29,580
China, People's Republic of	1,197	10,983	8,619	44,313	--	511	184,231	NA
France	--	--	595	--	--	2,087	33,057	82,804
Germany, East	862	--	1,619	--	--	4,483	15,432	NA
Germany, West	55	24,865	612	--	5,202	614	39,976	11,013
Italy	7,330	--	61	--	74,241	1,542	105,729	73,922
Japan	--	--	--	29,542	--	--	29,542	21
Korea, North	--	7,791	--	--	--	--	11,241	NA
Korea, Republic of	--	--	--	--	--	--	30,425	30,452
Mexico	--	--	--	--	924,234	--	991,025	1,126,531
Mongolia	--	--	--	106,152	--	--	106,152	NA
Mozambique[3]	--	--	--	--	5,256	--	8,113	--
South Africa, Republic of	--	--	1,168	--	29,115	1,954	163,296	137,845
Spain	7,330	--	--	--	134,840	859	199,930	194,885
Thailand	--	--	--	57,651	--	--	320,020	NA
Tunisia	2,359	--	--	--	6,002	--	32,712	NA
U.S.S.R	--	--	--	--	--	--	2,500	3,527
United Kingdom	18,079	287	353	--	--	776	48,504	73,019
United States	220	--	--	--	--	--	3,882	2,763
Other and/or unspecified	125	--	1	21,275	2,641	5,178	172,099	NA
Total	37,557	43,926	13,028	258,933	1,181,531	18,004	2,503,779	NA

NA Not available.

[1] Detail on sources, unless otherwise specified, are from import data of countries listed as destinations, and figures in the total receipts column for each listed source are summations of reported imports of the listed destinations. Figures in the column headed total recorded exports are from the export statistics of the listed source countries. Differences between total receipts and total recorded exports are attributed chiefly to the time lag between date of shipment and the date of receipt, but some differences may result from either (1) concealment policies of some countries, and/or (2) reshipment of material by intermediate countries which may be credited as the origin in the trade returns of final receipt countries.

[2] Data are for year beginning July 1, 1972.

[3] Mozambique reports no production or exports of fluorspar; apparently the imports recorded by three nations from Mozambique were shipped from other countries by way of Mozambique.

[4] India records 4,853 short tons as being imported from Switzerland.

[5] West Germany records 109,691 short tons total imports from undisclosed origins (plus 297 short tons from countries specifically identified but not listed in this table).

[6] Countries included and total imports by each in short tons are: Denmark 3,078; Finland 5,648; France 4,162; Yugoslavia 5,116.

[7] Includes feldspar.

China People's Republoc of.—Fluorspar production in the People's Republic of China (PRC), was officially reported to be 280,000 tons in 1972 and 1973 but was verbally reported to be in excess of 300,000 tons in 1973. Chekiang, Hopeh, and Kwangsi Chuang Provinces were historically the principal sources of fluorspar. However, the largest single producing mine in recent years has been Tauling in Hunan Province where ore assaying about 12% fluorspar, 2% zinc, and 1% lead is mined and upgraded in a flotation plant. Concentrate assaying 95% to 97% CaF_2 is produced, and apparently used domestically in the chemical and aluminum industries.

Production from the older mining districts is mostly met-spar. PRC exported about 175,000 tons of fluorspar to Japan during 1973, all met-spar. In 1972 and 1973 a total of about 55,000 tons of met-spar was exported annually to various other countries such as the U.S.S.R., Belgium, West Germany, Poland, Finland, and Australia.

The iron and steel industry of the PRC consumes large quantities of met-spar, although the tonnage is difficult to estimate. The aluminum industry may have used 12,000 tons of acid-spar in 1973. Another 12,000 tons of acid-spar might also have been consumed by the chemical industry.

At the Chanchiang chemical fertilizer plant in South China's Kwangtung Province, where phosphate products were produced, sodium fluosilicate reportedly was also recovered from hitherto discarded waste materials. This additional fluorine supply is probably used in the PRC chemical industry.

Italy.—Italy has the capacity to produce over 330,000 tons of acid-spar and met-spar annually, but production in 1973 was only 259,630 tons, a 15% drop from 1972 and about 20% drop from the 1971 peak production of about 326,000 tons. Acid-grade fluorspar exports to the United States declined from 74,000 in 1972 to 58,000 in 1973.

In the past 3 years, extensive exploration for fluorspar has been underway, particularly on Sardinia. At the beginning of the year, there were about 10 companies actively mining, developing, or exploring for fluorspar including one major Australian company, Southland Mining Ltd., which controls Società Richerche Coltivazione Minerarie, (SRCM). Normally over 20 mines operated on the mainland and Sardinia.

Southland Mining announced that it is heading a consortium to exploit the Pianciano fluorspar deposit located about 25 miles north of Rome.[4] Reserves of this high clay and carbonate fluorspar ore, in pyroclastic lacustrine sediments, were reported at 8 million tons containing about 55% CaF_2, 9% barite and celestite, and 6% apatite. The matrix is predominantly kaolinite of pyroclastic origin. Numerous companies have made feasibility studies of this deposit, but to date the ore has defied conventional means of heavy-media or froth-flotation processing. SRCM plans to process this pyroclastic material using a hydrocycloning technique and then make a briquet of about 70% CaF_2.

Italy's consumption of met-spar in steel manufacture peaked at about 120,000 tons annually; but due to the recent slump in steel output, consumption was probably less than 100,000 tons in 1973. The country has a plentiful supply of acid-spar but is short of met-spar. Italy requires supplementary imports from France, Mexico, the United Kingdom, the Republic of South Africa, and Tunisia. The physical and mineralogic character of the fluorspar deposits in Italy require flotation plant processing. Consequently, acid-spar production is in excess of internal needs.

Japan.—Japan continues to be the second largest fluorspar consumer in the free world, and is presently twenty-third on the list of fluorspar-producing countries. Japan's 1973 imports totaled about 631,000 tons. About 265,700 tons was imported from Thailand, 174,500 tons from PRC, about 125,200 tons from Republic of South Africa, 26,600 tons from Kenya, and 19,300 tons from Republic of Korea (South), mostly as met-spar. Japan's production totaled about 9,000 tons, all from one mine with dwindling ore reserves.

Japan's consumption totaled about 596,000 tons of all grades of fluorspar. As reported in the Japan Metal Journal, 381,830 tons of fluorspar or about 64% of the imports was used in the iron and steel industry. This indicates that the iron and steel industry, which produced about 132 million tons of primary steel in 1973, used 5.8 pounds of met-spar per ton of steel. Japanese steel companies continued their search for a substitute flux to use in steel furnaces, but to date no satisfactory universal substitute has been developed. Japanese companies have learned to use some of the new cheaper substitutes for starting a steel melt intended for certain types of steel products, and to use fluorspar flux more sparingly, thereby reducing the pounds of fluorspar used per ton of steel.

About 101,400 tons, mostly acid-spar, re-

[4] Industrial Minerals. Southland Takes Control of Fluorite Deposit. July 1973, p. 22.

presenting about 17% of the total, was directed into the aluminum industry. About 1,209,000 tons of aluminum was produced in 1973, indicating that about 168 pounds of acid-spar was used per ton of aluminum metal. This consumption rate confirms the reported consumption rate of aluminum fluoride and synthetic cryolite.[5] In addition Japanese aluminum companies recovered and recycled 26,300 tons of synthetic cryolite particulates, equivalent to about 31,500 tons of acid-spar. The use of recycled particulates has softened demand for synthetic cryolite produced from hydrofluosilicic acid (H_2SiF_6). About 90,900 tons of acid-spar was used in the inorganic chemical industry, and the balance was used in other unspecified industries.[6]

The Japanese fluorspar industry has both upgrading and froth flotation plants for processing imported ore. The chemical industry also has plants making hydrofluoric acid, sodium aluminum fluoride and aluminum fluoride from acid-spar, and a new processing plant for making sodium aluminum fluoride from imported sodium fluosilicate (silicofluoride.) Although the aluminum industry has been the largest consumer of acid-spar, the demands of the expanding fluorocarbon industry may soon surpass aluminum industry demands.

The Environmental Agency (EA) of Japan began studies aimed at establishing new environmental quality standards for all fluorides, based on their adverse effects on plant life. Present fluoride controls were restricted to airborne emissions from aluminum refining plants, glass factories, and brickyards. At midyear, the Chiba Prefectural Pollution Countermeasures Bureau announced that fluoride pollution in the Keiyo Coastal Zone has increased to 3.6 times the 1972 pollution. The EA planned to set the standard low enough to preclude damage to farm products, which are most susceptible to this air pollutant.[7]

Kenya.—Production of met-spar in Kenya increased 18,000 tons in 1973 to about 29,500 tons. A further increase of about 10,000 tons is expected in 1974. The Fluorspar Co. of Kenya, 51% owned by the Government of Kenya, 24.5% by Bamburi Portland Cement Co., and 24.5% by Continental Ore Corp., started construction of a froth flotation plant with a planned output of 120,000 tons annually, which is scheduled to go onstream in late 1975 or early 1976. Continental Ore Corp., a subsidiary of International Minerals and Chemical Corp., is the mine and mill operator.

Export shipments from Kenya have gone to many different countries. However, Japan contracted to purchase 10,000 tons of met-spar in 1973, and intends to buy even larger quantities of both met-spar and acid-spar in the future.

Proven ore reserves in the Rift Valley are said to exceed 6 million tons. Ore was reportedly high grade, although exact quality has not been divulged. It is estimated that another 9 million tons of so-called fluorspar resources will be available for future development.

Mexico.—Mexico maintained its position as the leading world producer and exporter of fluorspar and the foremost supplier to the United States. Although most Mexican companies expanded capacity considerably in 1971–72, the country's 1973 production only increased 4% to 1,197,000 tons, which is still below the peak of 1,302,000 tons in 1971. The majority of the larger companies increased output capacity in 1973. As a result six major companies produced about 79% of the national total.[8]

Mexico's exports of met-spar to the U.S. in 1973 exceeded the acid-spar exports by 21% whereas in 1972 the exports of these two grades were about equal. Mexico provided 74% of U.S. imports in 1973, a decrease of about 3.5% from 1972. Mexico exported over 90% of its production, and fluorspar continued to be Mexico's single most important mineral export. The value of Mexican fluorspar exports increased about 4.7% even though there was an increase in met-spar exports and a decrease in acid-spar exports.

No significant increase in Mexican fluorspar consumption was reported for 1973. The steel industry remained the largest consumer. The chemical and aluminum industries used much smaller amounts. Two small plants were reported to have a com-

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[5] Japan Metal Journal. Imports of Fluorspar in 1973. May 6, 1974, p. 11.

[6] Light Metal Statistics in Japan, 1972. Japan Light Metal Association, 1973, pp. 64–67.

[7] U.S. Embassy, Tokyo, Japan. Selected Science and Technology Items from the Japanese Press. State Department Airgram, A-804, August 1973, p. 5.

[8] Business Trends. Mining. V. IX, No. 373, Mar. 11, 1974, p. 6.

bined output of 20,000 tons annually of hydrofluoric acid: One is controlled by Allied Chemical Corp. and the other by Industrias Químicas.

Progress continued on construction of the 70,000-ton-per-year hydrofluoric acid plant being built west of Matamoros by Química Fluor, S.A. de C.V. The plant is jointly owned by the Mexican Government (Comisíon de Fomento Minero), E. I. du Pont de Nemours & Co., Minera Frisco, S. A., and Banco de Commerico. Du Pont is the plant builder and operator and expects to have the plant onstream by mid-1975.

The Las Cuevas mine in San Luis Potosí is the largest fluorspar mine in the world. It is owned by Cía. Minera Las Cuevas S.A., an affiliate of Empressa Fluorspar, which is a subsidiary of Noranda, Mines Ltd. Toronto, Canada. In 1973 they shipped about 338,000 tons of met-spar, including 79,000 tons of met-spar fines that were sold to fluorspar briquetting companies in the United States.[9] During 1973 Las Cuevas operated its new flotation plant, which has a 50,000-ton-per-year capacity, but the concentrate was stockpiled at the mine and not sold. About half of its ore was shipped from Tampico to U.S. and Canadian ports, and the other half was freighted to the Port of Brownsville, Tex., for subsequent distribution.

Other major producing companies included Industrias Peñoles, S.A., in San Luis Potosí and Guanajuato; Fluorita de Mexico, S.A., in Coahuila and San Luis Potosí; Minera Frisco, S.A., in Chihuahua; Reynolds Fluorspar, S.A., in Coahuila; Compania Minera Domincia, S.A., in Coahuila; Asarco Mexicana, S.A., in Chihuahua; and Compania Minera Rio Colorado, S.A., in Guanajuato.

During 1973, the Mexican fluorspar miners wage scale was increased 37% by order of the Mexican Government. Although smaller companies have been forced to raise prices on exported fluorspar, the major met-spar producing companies were able to hold prices fairly steady, in spite of rising production costs, and pressure from the smaller producers to raise the price.

Morocco.—Although no production was reported from Morocco during 1973, it was reported that development of a fluorspar deposit in the El Hammam region, 31 miles southwest of Meknes, and the construction of an acid-spar flotation plant with a 60,000 ton per year output capacity, were underway. Production from this 3 million ton deposit is expected late in 1974.

Production of hydrofluosilicic acid (H_2SiF_6) is planned for 1974. Both the Maroc-Chimie and the Maroc–Phosphore phosphoric acid plants, controlled by the Office Cherifien des Phosphates (OCP) are expected to produce H_2SiF_6 as a byproduct. The H_2SiF_6 by-product potential of the phosphate industry in Morocco could total 100,000 tons annually within a few years.

South Africa, Republic of.—Fluorspar production showed little change from the 1972 level, registering about 232,000 tons. Export sales of acid-spar, however, increased sharply during the last quarter of 1973. Probably some of the oversupply that had accumulated during 1972 was sold in 1973. Local sales were made mainly to the steadily expanding steel and aluminum industries.

At the Buffalo fluorspar mine of General Mining and Finance Corp. Ltd., it was announced that a new flotation plant designed to increase the company's output from 40,000 to 150,000 tons of acid-spar per year was operating at near capacity. However, due to a weak market, the old 40,000-ton-per-year mill was placed on standby. The 20-million-ton ore body averages 70 meters (210 feet) in width and was reported minable by open pit methods. The ore ranges from 13% to 25% CaF_2. Due to the limited supply of water and fears of fluorine pollution, even tailings are filtered for maximum recovery and reuse of water.[10]

A verbal source of information reported that the Phelps Dodge Co. of South Africa had reactivated an old flotation plant south of Zeerust in West Transvaal. Original annual capacity of 20,000 tons will be expanded to 30,000 tons of acid-spar through modernization of facilities. The company's deposit can be mined by open pit methods and reportedly the ore averages 29% CaF_2.

It was evident from the notable increases in production and export of acid-spar, predictions, the possibility of expanding exports, and favorable geological reports of fluorspar occurrences, that the future of the industry depends on the marketability of

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[9] Noranda 1973 Annual Report. Empressa Fluorspar. p. 12.

[10] Mining Magazine. South Africa's Buffalo Fluorspar in Full Production. V. 129, No. 6, December 1973, p. 501.

flotation concentrates. It was questioned whether world acid-spar markets could absorb, by the end of 1975, a predicted production increase of 200,000 tons from South Africa, Europe and Kenya, and another 50,000 tons from Mexico. Therefore, it has been suggested that South African companies may be forced to briquet their oversupply of concentrates and sell fluorspar briquets to the growing world iron and steel industry.

Fluorspar reserves in the Republic of South Africa and the Territory of South-West Africa are still reported to be equivalent to about 40 million tons of 35% CaF_2. Although their largest deposits are low grade, ranging from 15% to 20% CaF_2, they are minable by open pit methods and are economically exploitable on today's market.

Spain.—At the start of 1973, there was a large oversupply of fluorspar ore in the stockpiles of Spanish producers. This oversupply was caused by accelerated production in 1972 and a soft European market during the latter part of 1972. In spite of a soft market during 1973, most of the stockpiles were reduced to reasonable tonnages by yearend. Spain's overall production was down from 444,290 tons in 1972 to about 430,000 tons in 1973. The reported 1971 and 1972 production data on fluorspar were questioned. Later it was determined that some of the production of crude ore, containing less than 50% CaF_2, had been incorrectly reported as a finished salable product containing an equivalent of 70% to 75% CaF_2 [11] and some had been processed in a flotation plant to produce acid-spar. Table 11 shows the adjusted acid-spar and met-spar production for 1971 and 1972 and the estimated production for 1973.

Spain's exports of all grades of fluorspar to the United States increased 31% from 135,000 to 177,000 tons. Total exports reported by the Spanish Customs Office increased 36% from 195,000 in 1972 to 264,000 tons in 1973.

Consumption of met-spar in Spain increased slightly, although consumption of all grades of fluorspar was about the same as in 1972. The hydrofluoric acid plant of Minerales y Productos Derivados, S.A. (Minersa) near the Port of Castro-Urdiales continued to increase its consumption of acid-grade fluorspar and output of cryolite and aluminum fluoride. Preliminary estimates indicate that Spain's total consumption of fluorspar probably was close to 200,000 tons for 1973.

Prices of some fluorspar products were temporarily down about 5% to 10% the first part of the year. Met-spar prices were a little stronger than acid-spar prices due to increased demand by the steel industry. The decrease in the peseta-to-dollar exchange ratio and the increase in shipping costs hurt the Spanish producers.

During the first part of 1973 Fluoruros S.A., 49% owned by the Bethlehem Steel Co., put into operation a new fluorspar concentration unit at the Espasa plant in the Asturias region. The input capacity of the unit was reported at 100 tons an hour, which should add about 20,000 tons annually to the 1972 output capacity of about 111,000 tons. A pelletizing or briquetting unit was put in operation at Mineraria Silius' flotation mill at Assemini to make use of the waste fines. It was announced that Fluoruros S.A. was also planning to add a briquetting unit to their flotation plant at Pinzales, Spain, during 1974.

Thailand.—During 1973, about 439,000 tons of fluorspar was produced, less than 1% increase over 1972. Most of the Thai production is exported. About 265,700 tons, 60% of the production, was shipped to Japan, and the rest went to the U.S.S.R., Australia, West Germany, and India.

The value of met-spar, f.o.b. Bangkok, decreased from an average of $36 per ton in 1972 to an average of $32.14 per ton in 1973. The price of acid-grade fluorspar remained unchanged at $65 per ton, f.o.b. Bangkok.

The Thai Fluorite Processing Co. Ltd. continued to operate its flotation plant at Ban Lard and produced about 50,000 tons of acid-spar of which about 30,000 tons was shipped to Japan. Universal Mining Co. Ltd. continued to operate its heavy-media separating plant in the Ban Hong district near Chiengmai, Lamphun Province.

Production in Thailand would probably have been larger if a few suppressing factors had not affected production. Heavy rains in the Lamphun district of northern Thailand destroyed roads and temporarily suspended fluorspar rail and truck shipments to Bangkok. Worldwide shortages of diesel fuel for freighters forced buyers to stockpile met-spar in the Bangkok area

[11] U.S. Embassy Madrid, Spain. Minerals Questionnaire, A-118, May 23, 1972, and A-99, May 9, 1973.

until lower priced shipping facilities could be obtained. Also, deposits that have been mined by cheap surface mining methods are becoming scarce in some of the older districts.

In January 1974, it was announced that a Thai-Australian enterprise intended to build in the Cha-am Area a $2 million froth flotation plant to produce 150,000 tons annually of chemical grade fluorite.[12]

Tunisia.—Fluorspar output from Tunisia remained the same as in 1972 at 51,000 tons. Value per ton of exports increased about 5% but the quantity exported remained the same at about 46,000 tons. The fluorspar mines are located in the Zaghouan region of central Tunisia. Two new mines at Sta and Jebel Ouest started production in 1973. Fluorspar reserves in Tunisia were reported to be 6 million tons, currently minable on today's market, and 5 million tons of potential ore.

A French company, Huertey, and its Swiss associate, Buss, signed an agreement with the Tunisian Government to build an aluminum fluoride plant located in Gabes. The company will be controlled by Industries Chimiques de Fluor and construction will start in 1974.

United Kingdom.—Production continued at the same level as during 1972 and was estimated at 220,000 tons. The closing of the coal mines by labor strikes and a general business slump caused a weakness in internal demand. The United Kingdom was still self-sufficient in fluorspar. Exports dropped notably.

A conservative estimate of fluorspar ore reserves for 1973 was reported to be about 28.5 million tons of 35% CaF_2. A thorough evaluation of fluorspar deposits in the United Kingdom would probably increase reserves by an additional 15 million tons; but until the deposits can be more closely identified and evaluated, the additional tonnage must be treated as a resource. The largest fluorspar deposits are located in the Derbyshire Area of the southern Pennines in northern England. Most of the fluorspar produced in the past 10 years has come from this area. The deposits occur as nearly vertical replacement veins up to 80 feet (25 meters) in thickness. A few stratiform-type deposits containing large tonnages were among the first to be mined primarily for fluorspar. Lead and zinc sulfides and some barite are scattered through the matrix. For many years, starting at the beginning of the twentieth century when fluorspar first came into demand for the steel industry, the waste dumps of the old lead-zinc mines in the Derbyshire Area were the main source of fluorspar.

In the Pennines, barite, galena, and sphalerite commonly occur in sufficient quantities as secondary minerals to be recovered as byproducts from the fluorspar flotation plants. In the southwest England fluorspar area, fluorite is a common mineral constituent of primary lead and copper lodes. This area promises to be a potential producer of fluorspar as a byproduct.

Froth flotation plants in the United Kingdom have the capacity to produce over 200,000 tons annually of acid-grade fluorspar. If the demand were sufficient, the mines have the capacity to produce over 150,000 tons of metallurgical-grade fluorspar per year.

TECHNOLOGY

In September 1973, it was announced that Alcoa had broken ground near Palestine, Tex., for a commercial aluminum ingot plant using the new Alcoa smelting process. This process is described as a revolutionary energy-saving method. The plant will require about 2 years to build. The annual output of primary aluminum is reported to be 15,000 tons initially and 300,000 tons potentially. The new process combines alumina and chlorine in a reactor unit, forming aluminum chloride, which is processed electrolytically in an enclosed cell. The molten aluminum separates from the chlorine, permitting the chlorine to be recycled. No fluorine or fluorine compounds are used.[13]

Tests continued on synthesizing an artificial blood from fluorocarbons to use as a substitute for blood in animals. Efforts were concentrated on experiments using fluorocarbon compounds mixed with blood plasma and hemoglobin. Upjohn Co. reported a new compound called "Flurbipro-

[12] Modern Asia. Joint Ventures. V. 8, No. 1., January/February 1974, p. 34.

[13] Chemical Marketing Reporter. Alcoa Smelting Process is Getting its First Plant. V. 204, No. 12, Sept. 17, 1973, p. 32.

fen," which effectively reduces platelet aggregation in both human and animal bloods.

A nuclear bombardment method for the recovery of fluorine from waste plastics has been developed by the Takasaki Research Establishment of the Japan Atomic Energy Research Institute. The recovered plastic particles of micron size, contain polytetrafluorethylene, which is reusable for mixing into plastics to make lubricants. This process is attractive because it proposes reuse of the fluorine and eliminates fluorine emissions.[14]

A self-lubricating fluoride metal composite material was licensed by the National Aeronautics and Space Administration (NASA) to Astro-Met-Associates of Cincinnati, Ohio. The fluoride composites are impregnated into porous nickel, cobalt, or iron alloys permitting continuous lubrication.

Fluorosilicone grease, as a sealed lubricant, has found many new uses where the lubricant must be thermally stable, chemically inert, and where the rate that the lubricant is fed into the seal at high process temperatures and rotational speeds must be controlled. New uses for fluorosilicone greases have resulted in new pump designs and new automatic grease applicators.[15]

CRYOLITE

Natural cryolite was imported from Greenland (24 tons) and Denmark (2,200 tons). Although mining at the Ivigtut mine in Greenland stopped in 1962, each year since then, some ore was shipped from stockpiles. In Denmark where large tonnages of Ivigtut ore were stockpiled years ago, there is a modern heavy-media and flotation plant for concentrating the cryolite ore, which contains 60% cryolite, 10% siderite, 20% quartz and topaz, 6% fluorspar, and 2% other sulfides. An elaborate flotation plant separates the sulfides, carbonates, and quartz; but to separate the fluorspar and cryolite, they use a two-stage hydrocyclone installation to achieve about 97% recovery of the cryolite. Each year the tonnage produced becomes smaller as the stockpiles are depleted.[16]

All other cryolite production throughout the world was synthetic cryolite, a sodium aluminum fluoride (Na_3AlF_6). This insoluble inorganic salt, also called sodium fluoaluminate, is manufactured from caustic soda, alumina, and hydrofluoric acid. The output of one ton of synthetic cryolite requires approximately 1.2 tons of fluorspar containing 97% CaF_2, 1.6 tons of H_2SO_4, 0.4 ton of $Al_2O_3 \cdot 3H_2O$, and 0.6 ton of NaOH. During 1973, the price of synthetic cryolite was quoted in the Chemical Marketing Reporter at $336 per ton in bulk quantities. In recent years, consumption of synthetic cryolite, used mostly in the liners of the aluminum electrolytic cell, has been on the decline and more aluminum fluoride than Na_3AlF_6 is added directly in the flux.

Table 13 is no longer representative of a natural mineral or a beneficiated mineral product. It includes a natural and manufactured product and the tonnage represents only a small portion of the total synthetic cryolite that is actually consumed in the United States.

[14] Chemical Age International. Fluorine Containing Waste Plastic Converted to Powder. V. 107, No. 2824, Aug. 31, 1973, p. 13.

[15] Miller, J. W. Super-Lube Systems Eliminate Shaft-Seal Leakage. Chemical Eng., v. 80, No. 16, July 9, 1973, p. 88.

[16] World Mining. Cryolite Concentrator in Copenhagen. V. 9, No. 8, March 1973, pp. 60–63.

Table 13.—U.S. imports for consumption of cryolite [1]

Year and country	Short tons	Value (thousands)
1970	21,399	$4,666
1971	23,127	5,056
1972	25,642	3,541
1973:		
Canada	1,205	289
Denmark	2,244	560
France	551	111
Germany, West	248	91
Greenland	24	8
Italy	5,623	1,655
Japan	[2] 9,632	2,257
Mexico	226	68
Netherlands	36	13
Total	[3] 19,789	5,052

[1] Only the material from Greenland and Denmark is natural cryolite. All the rest is manufactured synthetic cryolite.

[2] Adjusted by Bureau of Mines. Division of Nonmetallic Minerals—Mineral Supply.

[3] Surinam and Switzerland were deleted because the imports were misclassified.

Gallium

By E. Chin [1]

Domestic production of gallium in 1973 increased. Most of the output continued to be used in producing intermetallic compounds such as gallium arsenide and gallium phosphide, which were used to manufacture light-emitting diodes for optoelectronic visual display panels. Sales of gallium-compounds for optoelectronic devices were estimated at $25 million in 1973, up from $4.5 million in 1972.

Estimated world production of gallium arsenide exceeded 10 metric tons. Almost 1 ton of gallium phosphide was produced. Data on world production of gallium metal are not available.

Table 1.—Salient gallium statistics
(Kilograms)

	1970	1971	1972	1973
United States:				
Production ------	W	W	W	W
Imports for consumption --	1,005	2,671	6,066	11,124
Consumption ----	[e] 1,100	2,289	5,076	8,496
Price per kilogram dollars--	750	750	750	750

[e] Estimated. W Withheld to avoid disclosing individual company confidential data.

DOMESTIC PRODUCTION

Production of gallium metal in 1973 by two companies was almost double that in 1972.

Gallium metal was produced as a by-product of alumina production by the Aluminum Co. of America (Alcoa) at its Bauxite, Ark., plant. Gallium metal, oxide, and trichloride were produced by Eagle-Picher Industries, Inc., at its Quapaw, Okla., plant. In addition, gallium metal and compounds derived primarily from imported material were produced by Atomergic Chemetals Co. (Atomergic), Cominco American, Inc., European Electronics, Inc., B. Freudenberg, Inc., Indium Corp. of America, and Kawecki Berylco Industries, Inc. Canyonlands 21st Century Corp. (Canyonlands) produced gallium from processing scrap generated from the production of gallium-arsenide single crystals at Blanding, Utah.

Alcoa began construction of a new gallium extraction and refining plant at Bauxite, Ark. The new facility, which was expected to be completed in mid-1974, will add to the existing gallium production capacity. The $1 million plant is being built to meet the increase in demand from the electronics industry and will use Alcoa proprietary gallium production technology.

CONSUMPTION

The largest use of gallium was in optoelectronic applications, principally in the form of gallium arsenide and gallium phosphide, which are used in light-emitting diodes (LEDS). LEDS emit infrared light, have a long service life, and consume little electrical power. Due to the pronounced trend of the electronics industry towards microminiaturization, LEDS were increasingly used in visual display systems in calculators, digital clocks and watches, medical instrumentation, multiple warning lights, and instrumentation for aircraft and automotive dash panels. More sophisticated monolithic light-emitting structures for full alphabet presentation are being developed which will require even greater quantities of intermetallic materials. Gallium arsenide continued to have extensive application in the field of microwave devices, where it operates efficiently beyond the cutoff frequencies of silicon-base diodes. The manganese-doped magnesium-gallium spinel ($MgGa_2O_4$: Mn) is a green phosphor used in ultraviolet

[1] Physical scientist, Division of Nonferrous Metals—Mineral Supply.

excitation and was used in fluorescent lamps in Xerox copying machines. Gallium compounds were also used in semiconductor applications for microswitching devices and in laser applications. The intermetallic compounds, vanadium-gallium and columbium-gallium, were used as superconductors with a high transition temperature and a high critical field.

Approximately 98% of the gallium consumed in 1973 was for electronic applications. Major consuming firms included Bell & Howell Co., Bell Telephone Laboratories, Inc., Hewlett-Packard Laboratories, Laser/Diode Laboratories, Inc., Litronix Inc., Monsanto Co. (Monsanto), Motorola, Inc., Opoca, Inc., RCA Corp., Texas Instruments, Inc., Texas Materials Laboratories, Inc., and Western Electric Co.

Atomergic at Carle Place, N .Y., in conjunction with BDH Chemicals, Ltd., of the United Kingdom, increased production capacity for epitaxial gallium arsenide. Atomergic offered a comprehensive array of gallium arsenide crystals. Materials Research Corp. (MRC), Orangeburg, N.Y., and Texas Instruments, Inc. (TI), Dallas, Tex., entered into a contract whereby MRC will supply TI with production quantities of high-purity gallium arsenide crystals for use in manufacturing LEDS. Monsanto announced a multimillion-dollar expansion program for its electronic materials and optoelectronics group including the construction of additional facilities at St. Peters, Mo., which will double its capacity to manufacture III–V materials. Monsanto will also establish a new headquarters site for optoelectronic devices in Stanford Industrial Park, Palo Alto, Calif. The new facilities were expected to be in operation in the first quarter of 1974. National Semiconductor Corp. (National), Santa Clara, Calif., manufactured LEDS, transistors, and integrated circuits.

Table 2.—Consumption of gallium, by end use

(Grams)

	1972	1973 p
Alloys [1]	31,116	30,597
Electronics [2]	4,965,717	8,349,910
Research and development	78,670	115,865
Unspecified uses	702	100
Total	5,076,205	8,496,472

p Preliminary.
[1] Specialty alloys.
[2] Light-emitting diodes, semiconductors, and other electronic devices.

STOCKS

Consumer stocks of gallium metal, low- and high-purity grades, totaled 1,091,203 grams as of December 31, 1973. Stocks a year earlier were 1,141,050 grams. Gallium metal stocks, held by producers and suppliers were as follows:

	Grams
Yearend—	
1971	402,875
1972	1,005,945
1973	948,947

Table 3.—Stocks, receipts, and consumption of gallium

(Grams)

Purity	Beginning stocks	Receipts	Consumption	Ending stocks
1972:				
97.0%–99.9%	16,955	10,591	12,692	14,854
99.99%	4,321	51,000	51,513	3,808
99.999%	615	10,249	1,664	9,200
99.9999%–99.99999%	130,938	5,992,586	5,010,336	1,113,188
Total	152,829	6,064,426	5,076,205	1,141,050
1973: p				
97.0%–99.9%	14,854	9,400	10,342	13,912
99.99%	3,808	8,670	10,759	1,719
99.999%	9,200	42,275	46,422	5,053
99.9999%–99.99999%	1,113,188	8,386,280	8,428,949	1,070,519
Total	1,141,050	8,446,625	8,496,472	1,091,203

p Preliminary.

PRICES

The average price per gram of gallium metal as quoted by domestic producers in 1973 was as follows:

Quantity	Purity		
	99.99%	99.999%	99.9999%–99.99999%
50 to 999 grams	$0.90	$1.05	$1.20
1,000 to 4,999 grams	.60	.65	.80
5,000 to 24,999 grams	.55	.60	.75

As the bulk of the demand for gallium is for high-purity metal (99.9999%+), published price quotations for low-grade materials were eliminated in midyear. Subsequently, prices were published only for dealers' and producers' quotes for high-grade gallium in 5-to-10 kilogram lots. Monsanto announced the reduction in prices for III–V material for the manufacture of LEDS and LED displays. Thin-film gallium arsenide-phosphide epitaxial wafer sold for $14 per square inch and was available for delivery from stock. The price of thicker epitaxial film products was reduced to $16 per square inch. The new prices became effective on November 15, 1973.

FOREIGN TRADE

Exports of gallium are not reported separately and are included in the category base metals and alloys, not elsewhere classified, wrought or unwrought, waste and scrap.

Total U.S. imports of gallium in 1973 were $11,124 kilograms, valued at $6,073,479, compared with 6,066 kilograms, valued at $2,715,179, in 1972. Shipments from Canada, the Netherlands, and Switzerland accounted for 89% of the total U.S. imports of gallium. The unit value of gallium imports ranged from $366 per kilogram for material from Italy to $1,307 per kilogram for gallium from Japan. The average unit value of all gallium imports in 1973 was $546 per kilogram.

Table 4.—U.S. imports for consumption of gallium (unwrought, waste and scrap), by country

Country	1972		1973	
	Kilograms	Value	Kilograms	Value
Canada	1,396	$696,186	2,133	$1,102,332
China, People's Republic of	--	--	4	2,652
Germany, West	124	45,479	388	166,765
Hong Kong	4	1,426	--	--
Hungary	2	680	--	--
Italy	156	45,369	486	177,882
Japan	16	5,985	142	185,606
Netherlands	146	74,015	641	395,836
Switzerland	4,127	1,795,792	7,134	3,923,547
United Kingdom	95	50,247	196	118,859
Total	6,066	2,715,179	11,124	6,073,479

WORLD REVIEW

Canada.—The Manitoba Research Council made a $23,800 grant to the University of Manitoba to study the feasibility of extracing gallium from tantalum tailings generated by Tantalum Mining Corp. of Canada, Ltd. (Tamco) at Bernic Lake. The university research team will work with Tamco on the project. The company will examine its production process to determine at which stage gallium concentration is at its maximum. Tamco mills about 150,000 tons per year of tantalite and estimated that about 1 pound of gallium might be available for each 2 tons of tantalum metal produced.

Cominco Ltd. (Cominco) recovered gallium as a byproduct of zinc refining at its smelting-refining-chemicals-fertilizer complex at Trail, British Columbia. Cominco's Technical Research Centre maintains active interest in electronic materials and directs commercial production of high-purity metals.

High-purity gallium was shipped to the Electronic Materials Division of Cominco Amercan Inc. in Spokane, Wash., for sale to consumers.

China, People's Republic of.—Gallium metal was listed for sale at the Canton Trade Fair in October 1973. However, only limited quantities of the metal were reportly available for trade. Four kilograms of gallium metal, valued at $2,652, was exported to the United States.

Japan.—Sumika Alusuisse Gallium Ltd. (Sumika), a company founded jointly by Sumitomo Chemical Co. and Swiss Aluminium Ltd., completed the construction of a plant in Nijhama on the Island of Shikoku for the production and refining of gallium. The gallium is to be recovered as a byproduct in the production of alumina.

World producers of gallium, by company, location, and raw materials source, are as follows:

Country	Company	Location	Source
Canada	Cominco, Ltd	Trail, British Columbia.	Zinc ore.
China, People's Republic of	NA	NA	NA.
Czechoslovakia	NA	NA	NA.
France	Alusuisse France S.A.	Marseilles	Bauxite.
Germany, West	Martinswerk G.m.b.H. fur Chemische und Metallurgische Produktion.	Bergheim/Erft	Do.
	Vereinigte Aluminum-Werke A.G.	Bonn	Do.
Hungary	NA	NA	NA.
Italy	Società Alluminio Veneta Azioni.	Porto Marghera	Bauxite.
Japan	Dowa Mining Co., Ltd	Kosaka	Zinc ore.
	Nippon Light Metal Co., Ltd.	Shimizu	Bauxite.
	Sumika Alusuisse Gallium Ltd.	Nijhama	Do.
	Toho Zinc Co	Fujioka	Zinc ore.
Norway	Vigeland Metal Refinery A/S.	Vigeland	Super-purity aluminum.
Switzerland	Alusuisse Research Laboratories.	Neuhausen am Rheinfall.	Crude gallium metal.
U.S.S.R	NA	NA	NA.
United States	Aluminum Co. of America.	Bauxite, Ark	Bauxite.
	Eagle-Picher Industries, Inc.	Quapaw, Okla	Zinc ore.

NA Not available.

TECHNOLOGY

The extraction of trivalent gallium from aqueous hydrochloric, nitric, and perchloric acid solutions by 1-phenyl-2-methyl-3-hydroxy-4-pyridone (HX) and 1-(4-tolyl)-2-methyl-3-hydroxy-4-pyridone (HY) dissolved in chloroform was studied.[2] From acid concentrations less than 3×10^{-2} molar (M), gallium was quantitatively extracted by both reagents. Zinc was not extracted by either HX or HY from $10^{-3}M$ to 3 M HCl, HNO_3, or $HClO_4$. On the basis of these differences, a rapid and simple method for the separation of gallium from zinc was described.

The transactions of a conference held at Great Gorge, N.J., on electronic materials processing were published by the Materials Research Corp.[3] Papers on the crystal growth of gallium arsenide and gallium phosphide, production of high-purity materials for electronic uses, and design of a reflective LED digit were included in the transactions.

Reports on the growth of crystals for electronic uses and the comparison of various

[2] Tamhina, B., M. J. Herak, and K. Jakopcic. The Extraction and Separation of Gallium From Zinc by Derivatives of Pyridone. J. Less-Common Metals, v. 32, No. 2, November 1973, pp. 289–294.

[3] Materials Research Corp. Electronic Materials Processing . . . From Substrate to Thin Film Device. Orangeburg, N.Y., 1973, 201 pp.

crystal growth techniques were published.[4] These studies covered the growth of substrate materials, the growth of epitaxial films, and the growth of large metal crystals composed of atoms that are arranged in a precise and periodic manner.

Intermetallic compounds are soft materials, subject to surface damage unless care is exercised in handling them. Techniques of etching and polishing gallium and other semiconductor compounds, currently being employed to produce quality (low-damage) crystal surfaces, were described.[5]

Papers characterizing the physical properties of semiconductor materials were published.[6] The delineation of electronic materials is important to the industry for process design, equipment selection, and economic evaluations.

Significant advances were made in gallium arsenide laser diode fabrication.[7] The width of operation was narrowed, and peak output power was increased. One gallium semiconductor laser was successfully operated for 3,000 hours, and it was expected that this laser would attain at least 10,000 hours of continuous operation.

Canyonlands conducted research to recover gallium from phosphorus dust, using a new hydrometallurgical process under license from Monsanto. The dust, which contains 500 parts per million of gallium, will be obtained from Monsanto and other sources.

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[4] Fairman, R. D., and R. Solomon. Submicron Epitaxial Films for GaAs Field Effect Transistors. J. Electrochem. Soc., v. 120, No. 4, April 1973, pp. 541–544.

Gentilman, R. L. Chemical Vapor Deposition of Epitaxial Films of Yttrium Iron Garnet and Gallium-Substituted Yttrium Iron Garnet and a Thermodynamic Analysis. J. Am. Ceram. Soc., v. 56, No. 12, December 1973, pp. 623–627.

Minden, H. T. A Comparison of Liquid Phase Epitaxy and Chemical Vapor Epitaxy of III–V Compound Semiconductors. Solid State Technol.. v. 16, No. 1, January 1973, pp. 31–38.

O'Kane, D. F., V. Sadagopan, E. A. Giess, and E. Mendel. Crystal Growth and Characterization of Gadolinium Gallium Garnet. J. Electrochem. Soc., v. 120, No. 9, September 1973, pp. 1272–1275.

[5] Jensen, E. W. Polishing Compound Semiconductors. Solid State Technol., v. 16, No. 8, August 1973, pp. 49–52.

Miller, D. C. The Etch Rate of Gadolinium Garnet in Concentrated Phosphoric Acid of Varying Composition. J. Electrochem. Soc., v. 120, No. 12, December 1973, pp. 1771–1774.

[6] Spitzer, S. M., B. Schwartz, and M. Kuhn. Electrical Properties of a Native Oxide on Gallium Phosphide. J. Electrochem. Soc., v. 120, No. 5, May 1973, pp. 669–672.

Williams, T. Photoluminescence Analysis of Semiconductors. Solid State Technol., v. 16, No. 4, April 1973, pp. 83.

[7] American Metal Market. Says It's Given Laser 'Commercial' Life. V. 80, No. 110, June 6, 1973, p. 8.

Marshall, S. Advances in GaAs Laser Diode Technology. Solid State Technol., v. 16, No. 12, December 1973, p. 77.

Gem Stones

By Robert G. Clarke [1]

The production value of gem stones and mineral specimens in the United States during 1973 was estimated to be $2.7 million, essentially equal to the value of production in 1972. Amateur collectors provided most of the material. A few small companies operated deposits for turquoise, opal, jade, emerald, and sapphire. These small companies sold mostly to wholesale or retail outlets and sometimes to jewelry manufacturers.

DOMESTIC PRODUCTION

Gem stone production was estimated to be $1,000 or more for each of 38 States. The following States accounted for 76% of the total production, in thousands: Oregon, $700; California, $220; Arizona, $170; Texas, $163; Washington, $160; Montana, $150; Wyoming, $142; Nevada, $140; Colorado, $131; and Idaho, $110.

The Yogo mine near Utica, Mont. was reopened by a new firm controlled by Sapphire International Corp.[2] The operation was described as employing 40 miners on two shifts, and daily ore production was 100 to 150 tons yielding 3,000 to 5,000 carats per day of a mix of good gem stones, imperfect stones, and chips. The aboveground washing plant operated about 6 months of the year, depending on the weather. Underground operations continued year-round. The sapphires from Yogo Gulch are a consistent corn-flower blue and are brilliant under artificial light.

Pala Properties, International, continued to work the Stewart Lithia mine and the Tourmaline Queen mine in the Pala district, San Diego County, Calif.[3] Good pockets of tourmaline matrix exhibiting deep rose coloring with green caps were uncovered in the Tourmaline Queen. Large tourmaline crystals, 2 inches in diameter and 4¾ inches long, were accompanied by quartz crystals 4 inches in diameter and 6½ inches long. The company also worked the White Queen mine where morganite was produced on an intermittent schedule and also planned to reopen the Pala Chief, Esmeralda, and the Himalaya mines.

Benitoite, one of the rarest gem stones, was produced from an open-cut mine in San Benito County, Calif.[4] The locality is near the headwaters of the San Benito River, about 25 miles north of Coalinga. Benitoite has a fire and dispersion very close to that of diamond; however, it has a hardness of 6.5 or less on the Mohs' scale.

Seashell and rock collectors at Miami Beach, Fla., found a large new source of material for their hobby.[5] A dredging project to deepen the shipping channel at the Port of Miami yielded about 400,000 tons of mixed material that contained a high percentage of coral and clam shells. The dredgings were put in numerous piles at the southern end of Miami Beach. An abundance of the coral and of the clam shells were infilled with yellow calcite crystals caused by fossilization. A mollusk paleontologist at the Rosenstiel School of Marine and Atmospheric Science, University of Miami, estimated the fossils to have a range in age from 100,000 to 1 million years.

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[1] Physical Scientist, Division of Nonmetallic Minerals—Mineral Supply.

[2] The Mining Record of Denver, Colorado. Yogo Mine in Montana is Reopened. V. 84, No. 34. Aug. 22, 1973, p. 2.

[3] California Geology. Mining Activity in California, July 1972–July 1973. V. 26, No. 12, December 1973, p. 294.

[4] Schiffman, W. Mine Produces Rarest of Gems. San Jose Mercury-News, July 22, 1973, p. 12.

[5] Gems and Minerals. Good News for Florida Rockhounds. No. 430, July 1973, pp. 40–41.

Touchstones were collected from gravel beds of the Coosa River system near Wetumpka, Ala., in Elmore County.[6] Touchstone, which has been used since ancient times by jewelers and goldsmiths, can give a precision of about 1 part in 100 in estimating the gold content of a gold-silver or gold-copper alloy. The stones from the Coosa River are also called tarbaby agates. The touchstone from the Coosa River is a deep velvet black variety of jasper and can be polished to a strikingly beautiful gem stone.

Two gem-quality diamonds, 2 to 2½ carats in weight, were reportedly found at the Crater of Diamonds State Park at Murfreesboro, Ark. Mr. J. Cannon, Superintendent of the Park, commented that the stones were of beautiful gem quality. Finders are keepers at the Park, and hence the value of the stones was unknown until the finders report appraisals.

Descriptions of field trips, events, and mineral and gem stone finds were reported regularly in the following publications: Gems and Minerals, Lapidary Journal, Mineralogical Record, and Rocks and Minerals.

Domestic Gem Stone Producers.—The Department of the Interior has received many inquiries regarding producers of gem stones. In response to these inquiries, the Bureau of Mines started an annual canvass in 1973. Quantity and value data were withheld to maintain confidentiality of the producers who responded to the canvass. The following lists producers by principal gem stone reported:

Emerald.—Big Crabtree mine, Mitchell County, N.C., operated by PBH Emerald Co., P.O. Box 163, Little Switzerland, N.C. 28749.

Jade.—Stewart mine, Kobuk Village, Alaska, operated by Stewart Jewel Jade Co., 531 4th Ave., Anchorage, Alaska 99501.

Opal.—Royal Peacock mine, Humboldt County, Nev., operated by Harry W. Wilson, Denio, Nev. 89404.

Spencer Opal mine, Clark County, Idaho, operated by Mark L. Stetler, 1862 Ranier Street, Idaho Falls, Idaho 83401. Mostly operated on a daily fee digging basis for amateurs.

Sapphire.—Chaussee Sapphire mine, Granite County, Mont., operated by Chaussee Sapphire Corp., P.O. Box 706, Philipsburg, Mont. 59858.

Sapphire Village mine (Yogo Gulch), Judith Basin County, Mont., operated by Sapphire International Corp., Utica, Mont. 59452.

Turquoise.—Blue Eye mine, Lander County, Nev. operated by Elmer F. Schroeder, Roderick Corp., Box 6, Crescent Valley, Nev. 89821.

Blue Jay mine, Esmeralda County, Nev., operated by M. C. Winfield, P.O. Box 813, Tonopah, Nev. 89049.

June #1 mine, Lander County, Nev., operated by W. H. Coplen, Box 301, Sells, Ariz. 85634.

Pinto Valley Turquoise Operation, Gila County, Ariz., operated by L. W. Hardy Co., Inc., 3809 E. Hwy. 66, Kingman, Ariz. 86401.

Tina Gem mine, Lander County, Nev., operated by R. G. Bonner, Box 948, Fallon, Nev. 89406.

Variscite.—Brown Claims, Esmeralda County, Nev., operated by C. R. Barbe, Box 187, Mina, Nev. 89422.

CONSUMPTION

Domestic gem stone output generally went to rock, mineral, and gem stone collections, objects of art, and jewelry. Apparent consumption of gem stones (domestic production plus imports, minus exports and reexports) was $423 million, equal to that of 1972.

PRICES

Prices of all gem stones increased during 1973. Price ranges in February 1973 for first-quality, cut and polished, unmounted gem diamond were as follows: 0.25 carat, $100 to $425; 0.5 carat, $300 to $1,000; 1 carat, $700 to $3,800; 2 carats, $2,300 to $12,000; and 3 carats, $4,100 to $25,000. The median price for each range in Feb-

[6] Mayo, R. Tarbaby Agate. Rocks and Minerals, v. 48, No. 1, January 1973, pp. 63–64.

ruary was 0.25 carat, $225; 0.5 carat, $550; 1 carat, $1,750; 2 carats, $4,750; and 3 carats, $9,500. A similar determination of price ranges in June 1973 was 0.25 carat, $100 to $450; 0.5 carat, $300 to $1,195; 1 carat, $800 to $5,000; 2 carats, $2,200 to $20,000; and 3 carats, $4,500 to $35,000. The median price for each range in June was 0.25 carat, $250; 0.5 carat, $595; 1 carat, $2,000; 2 carats, $4,950; 3 carats $11,950. Price data were not ascertained in the latter part of 1973 because of instability and conflict in international political affairs.

FOREIGN TRADE

Exports of all gem materials amounted to $333.1 million, and reexports to $186.8 million. Diamond comprised 94% of the value of exports and 93% of the value of reexports. U.S. exports of diamond in 1973, on which work was done prior to shipment, amounted to 259,119 carats valued at $314.2 million. Of this, diamond cut but unset, suitable for gem stones, not over 0.5 carat, was 44,714 carats valued at $16.7 million; and cut but unset, over 0.5 carat, was 214,405 carats valued at $297.5 million.

Reexports of diamond, on which no work was done, amounted to 1,467,234 carats valued at $173.9 million in categories as follows: Rough or uncut, suitable for gem stones, not classified by weight, 1,389,340 carats valued at $128.3 million; cut but unset, not over 0.5 carat, 35,579 carats valued at $9.0 million; cut but unset, over 0.5 carat, 42,315 carats valued at $36.6 million.

The six leading recipients of diamond exports accounted for 92% of the carats and 93% of the value and were as follows: Hong Kong, 69,071 carats valued at $97.2 million; Switzerland, 59,126 carats valued at $52.3 million; Japan, 53,592 carats valued at $51.7 million; the Netherlands, 30,037 carats valued at $53.9 million; Belgium, 19,878 carats valued at $30.8 million; and Israel, 7,395 carats valued at $6.3 million. The six leading recipients of diamond reexports accounted for 94% of the carats and 92% of the value and were as follows: Israel, 636,497 carats valued at $70.2 million; Belgium, 403,108 carats valued at $30.7 million; the Netherlands, 194,101 carats valued at $30.4 million; Switzerland, 124,715 carats valued at $19.3 million; Japan, 15,874 carats valued at $5.8 million; and Hong Kong, 9,075 carats valued at $2.8 million.

Exports of all other gem materials amounted to $19.0 million. Of this total, pearls, natural and cultured, not set or strung, were valued at $0.5 million. Natural precious and semiprecious stones, unset, were valued at $16.2 million; and synthetic or reconstructed stones, unset, were valued at $2.3 million. Reexports of all other gem materials amounted to $12.9 million. Reexports of pearls amounted to $0.8 million; of natural precious and semiprecious stones, unset, to $11.6 million; and of synthetic or reconstructed stones, unset, to $0.5 million.

Imports of gem material from 85 countries and territories increased 31% in value compared with that of 1972. Diamond accounted for 86% of the total value of gem material imports.

Most of the rough and uncut diamond imports were from seven countries, which accounted for 98% of this category as follows: the United Kingdom, 978,553 carats, $225.8 million; Sierra Leone, 747,000 carats, $78.9 million; Republic of South Africa, 426,881 carats, $83.7 million; Venezuela, 296,271 carats, $9.8 million; Central African Republic, 190,833 carats, $7.7 million; Belgium-Luxembourg, 68,056 carats, $16.8 million; and the Netherlands, 55,255 carats, $22.2 million. Of the imports of diamond, cut and unset, not over 0.5 carat, 89% was supplied by the following eight countries: Belgium-Luxembourg, 1,016,871 carats, $131.4 million; Israel, 774,090 carats, $106.6 million; India, 211,061 carats, $22.8 million; the U.S.S.R., 27,435 carats, $5.2 million; France, 23,485 carats, $2.4 million; the United Kingdom, 18,511 carats, $1.9 million; the Netherlands 15,158 carats, $1.7 million; the Republic of South Africa, 13,656 carats, $3.9 million. For diamond, cut and unset, over 0.5 carat, 99% came from the following seven countries: Belgium-Luxembourg, 142,001 carats, $45.8 million; Israel, 77,944 carats, $21.6 million; the Republic of South Africa, 10,070 carats, $8.9 million; the Netherlands, 2,832 carats, $2.4 million; India, 2,148 carats, $0.3 million; the U.S.S.R., 1,882 carats, $0.7

million; and the United Kingdom, 1,683 carats, $0.5 million.

Imports of emeralds increased 31% in quantity and 47% in value. Of 28 countries supplying natural emeralds to the United States, 10 countries accounted for 97% of the quantity as follows: India, 412,179 carats, $6.7 million; Brazil, 148,399 carats, $1.2 million; Colombia, 47,524 carats, $15.2 million; Hong Kong, 34,196 carats, $1.0 million; Switzerland, 27,840 carats, $2.9 million; the United Kingdom, 22,651 carats, $2.3 million; Israel, 13,771 carats, $0.6 million; the Netherlands, 9,652 carats, $0.1 million; West Germany, 9,419 carats, $0.2 million; and Belgium-Luxembourg, 3,478 carats, $0.2 million.

Imports of rubies and sapphires increased 47% and came from 30 countries. Eight countries accounted for 90% of the value of rubies and sapphires as follows: Thailand, $11.7 million; Hong Kong, $2.5 million; India, $1.4 million; Switzerland, $0.7 million; the United Kingdom, $0.6 million; France, $0.3 million, and Israel, $0.2 million.

Natural pearls and parts imported from India were valued at $260,000. Other leading suppliers of natural pearls and the value of imports were as follows: Italy, $33,100; Japan, $28,600; Hong Kong, $18,500; Switzerland, $10,500; Burma, $8,300; and Taiwan, $5,300. Imports of cultured pearls from Japan were valued at $8.4 million. Cultured pearls, also imported from Hong Kong were valued at $231,000; from Burma, $348,000; from Switzerland, $101,000; from France, $38,000; from Thailand, $22,000; from Italy, $19,000; from West Germany, $8,000; and from India, $8,000.

The imports of imitation pearls decreased two-thirds. Imports from Japan valued at $1.1 million comprised 85% of the total. Other countries from which imitation pearls were imported included: Spain, $78,000; Taiwan, $27,000; Australia, $7,000; Hong Kong, $5,000; the Republic of Korea, $4,000; and West Germany, $1,000. Smaller values also came from France, Switzerland, and Portugal.

Of 17 countries supplying imitation gem stones to the United States, 6 countries accounted for 78% by value, as follows: Austria, $4.0 million; West Germany, $2.8 million; Czechoslovakia, $0.8 million; Switzerland, $0.5 million; Japan, $0.3 million; and Denmark, $0.1 million.

Synthetic materials, gem-stone quality, cut but not set, and others, decreased about 3% in value. From West Germany, the value of synthetics was $4.8 million; from Switzerland, $1.2 million; from Japan, $1.0 million; from France, $0.8 million; from Taiwan, $0.7 million; from Israel, $0.5 million; from Hong Kong, $0.4 million; from Belgium-Luxembourg, $0.3 million; and from Austria, $0.2 million. These nine countries accounted for 98% of synthetic gem imports.

Table 1.—U.S. imports for consumption of precious and semiprecious gem stones

(Thousand carats and thousand dollars)

Stones	1972		1973	
	Quantity	Value	Quantity	Value
Diamonds:				
Rough or uncut	3,096	338,624	[1] 2,821	[1] 460,198
Cut but unset	2,410	288,055	2,360	360,892
Emeralds: Cut but unset	573	22,176	749	32,600
Rubies and sapphires: Cut but unset	NA	13,172	NA	19,336
Marcasites	NA	96	NA	28
Pearls:				
Natural	NA	571	NA	368
Cultured	NA	7,615	NA	9,232
Imitation	NA	3,707	NA	1,257
Other precious and semiprecious stones:				
Rough and uncut	NA	6,210	NA	5,859
Cut but unset	NA	17,238	NA	25,043
Other n.s.p.f.	NA	1,107	NA	1,532
Synthetic:				
Cut but unset number	16,957	10,571	16,365	10,066
Other	NA	165	NA	341
Imitation gem stones	NA	6,829	NA	10,906
Total	NA	716,136	NA	937,658

NA Not available.
[1] Adjusted by the Bureau of Mines.

Table 2.—U.S. imports for consumption of diamond (exclusive of industrial diamond), by country

(Thousand carats and thousand dollars)

Country	1971				1972				1973			
	Rough or uncut		Cut but unset		Rough or uncut		Cut but unset		Rough or uncut		Cut but unset	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Belgium-Luxembourg	88	9,092	1,036	113,626	64	10,706	1,211	147,392	68	16,836	1,159	177,222
Brazil	3	129	2	232	(1)	26	3	321	(1)	6	2	409
Canada	--	--	1	69	--	--	1	82	1	276	1	91
Central African Republic	208	6,785	--	--	207	6,587	--	--	191	7,668	--	--
France	21	634	31	2,514	33	1,564	23	1,895	6	169	24	2,441
Germany, West	1	121	2	210	(1)	31	3	324	1	301	1	94
Guyana	1	49	(1)	19	2	96	(1)	6	(1)	37	(1)	3
India	--	--	80	6,429	--	--	186	16,507	(1)	21	213	23,099
Israel	47	3,425	671	69,569	38	5,120	852	98,316	34	7,838	852	128,204
Japan	(1)	33	2	203	--	--	1	129	1	36	2	286
Liberia	17	3,797	(1)	66	3	1,611	(1)	67	7	5,192	(1)	406
Netherlands	31	6,190	20	2,440	37	10,948	15	2,266	55	22,209	18	4,143
Sierra Leone	281	14,331	4	527	164	15,593	3	324	[2] 747	[2] 78,919	(1)	40
South Africa, Republic of	904	83,389	25	6,388	953	100,059	27	8,286	427	83,707	24	12,833
Switzerland	16	3,149	11	1,156	47	2,269	8	1,188	1	181	5	1,429
U.S.S.R.	--	--	24	3,324	--	--	35	5,802	--	--	30	5,931
United Kingdom	947	118,913	12	1,366	1,302	178,659	32	3,586	979	225,802	20	2,415
Venezuela	177	4,283	--	--	244	5,118	--	--	296	9,839	(1)	12
Other	(1)	255	4	529	2	237	10	1,564	7	1,161	9	1,834
Total	2,742	254,575	1,925	208,667	3,096	338,624	2,410	288,055	[2] 2,821	[2] 460,198	2,360	360,892

[1] Less than ½ unit.
[2] Adjusted by the Bureau of Mines.

Marcasites, cut but not set, and suitable for jewelry were imported from four countries: Israel, $23,125; Switzerland, $3,644; Hong Kong, $850; and the United Kingdom, $450.

Precious and semiprecious stones, rough and uncut, amounted to $5.9 million in value of imports. Seven countries accounted for 92% of the value as follows: Colombia, $2.4 million; Brazil, $1.3 million; Australia, $0.8 million; the United Kingdom, $0.3 million; the Republic of South Africa, $0.3 million; Mozambique, $0.2 million; and Hong Kong, $0.1 million.

Precious and semiprecious stones, cut but not set, amounted to $25.0 million. Eleven countries accounted for 94% of the value as follows: Hong Kong, $9.4 million; Australia, $3.4 million; Brazil, $3.1 million; West Germany, $1.9 million; Iran, $1.4 million; Taiwan, $1.4 million; Japan, $1.0 million; Sri Lanka, $0.5 million; Mexico, $0.5 million; India, $0.5 million; and Switzerland, $0.5 million.

Coral and cameos, cut but not set, were imported from Italy, $1.2 million; from Japan, $0.5 million; and from Taiwan, $0.3 million. Minor quantities of coral and cameos were also imported from the United Kingdom, France, West Germany, Switzerland, Israel, Singapore, the Philippine Republic, Hong Kong, the People's Republic of China, Australia, and Egypt.

WORLD REVIEW

Angola.—Companhia de Diamantes de Angola (DIAMANG), the only diamond producer, reported an increase in export value in 1972 of 4% to $63.4 million owing to an increase in the percentage of gem stones produced.[7] The quantity of diamond exported in 1972 decreased 6% to 2.2 million carats. All diamond exports go to metropolitan Portugal. The Consorcio de Diamantes de Angloa, the consortium of DIAMANG and De Beers interests that inherited all but 50,000 square kilometers of DIAMANG's former concession area, continued active exploration. A number of promising kimberlite deposits were found, but no plans were made for immediate exploitation.

Australia.—Large deposits of high-quality nephrite jade were discovered near Cowell, a town in the east coast of Eyre Peninsula, about 125 miles northwest of Adelaide, South Australia.[8] A newly formed company, Jade Australia Proprietary Ltd., Adelaide, was reported to have extensive proven reserves.

According to Australian sources, its 300 sapphire mines produce sapphires valued at $15 million and account for 80% of the world volume of sapphire and 50% of the world sapphire value.[9]

Botswana.—Development of a second large diamond mine is expected.[10] The Government of Botswana and De Beers Botswana Mining Co., discussed development of the DK 1 kimberlite pipe 25 miles southeast of the existing Orapa mine, which currently produces 2.4 million carats worth about $30 million per year. The mine at DK 1 could be operating within 18 months after agreements are reached.

Burma.—Burma's Ninth Annual Gem, Jade, and Pearl Emporium was held February 19–24, 1973. Jade sold amounted to $4,307,000; gems, to $281,000; and pearls, to $1,247,000. The total amounted to $5,835,000, a record high. The increase was due primarily to rising world prices of jade rather than an increase in the quantity of jade, or gems, or pearls. Attendance was by 12 countries, 151 firms, and 219 persons. Hong Kong buyers took 119 lots of jade out of the 156 lots sold. The People's Republic of China delegation bought 27 lots of jade, and Japanese buyers bought 9 lots. One bidder from the United States bought one lot of jade. Neither gems nor pearls were bought by U.S. bidders. Motivated by the success of the Ninth Emporium, the Government held a special emporium in August 1973 for jade and pearls, omitting gem stones. At the special emporium, jade sales amounted to $5.3 million. Hong Kong dealers monopolized the buying of jade, accounting for 72 lots of the 81 sold. Burmese authorities assert that reserves of jadeite are adequate

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[7] U.S. Bureau of Mines. Angola. Mineral Trade Notes, v. 70, No. 8, August 1973, pp. 8–9.

[8] Stone, J. Massive Jade Discovery in South Australia. Calif. Min. J., v. 42, No. 11, July 1973, p. 24.

[9] Jewelers' Circular-Keystone. Briefly. Australia Becomes a Major Source of Sapphires. V. 64, No. 3, December 1973, p. 97.

[10] Engineering and Mining Journal. In Africa. Botswana. V. 174, No. 12, December 1973, p. 127.

and that prospects are good for locating additional deposits.

Canada.—Pacific Jade Industries, operators of all nephrite jade mines near Ogden Mountain, British Columbia, reported 1972 jade sales of nearly $200,000, over half of which was sold to the People's Republic of China.[11] Exports to other countries included West Germany, Hong Kong, Singapore, and Japan. The most precious jade is generally apple-green in color, translucent, free of flaws, and free of color variations. Variations in color can be almost white or black and all shades of green in between. The value of jade sold ranged from $1 to $30 per pound, averaging about $3.30 per pound. In addition to selling crude jade, Pacific Industries also marketed finished pieces ranging from inkstands and paper weights to works of art.

Central African Republic.—Cominco, Ltd., a Canadian company and Diamond Distributors, Inc., of New York formed a new company, Société Centraficaine d' Exploitation Diamantifere, to conduct diamond mining and exploration in the Central African Republic.[12] Cominco, which has the majority interest, will manage the new company and provide technical direction; Diamond Distributors, Inc., will be responsible for marketing. In the Central African Republic, 60% of the amount of diamond recovered is from the Upper Sangha (Carnot, Berberati, and Nola regions); the remainder is from the northern (Bamingui-Bangoran) and eastern (Haute-Kotte) areas.[13] About 45,000 workers were employed in 1973 to gather diamond from alluvial deposits.

Colombia.—The Government-owned emerald mines at Muzo, Coscuez, and Peña Blanca were closed in July 1973 and the operations landfilled to conserve the unmined emeralds. The emerald mine areas were placed under Colombian Army control. Negotiations were underway between the Ministry of Mines and private operators to arrange the reopening of the mines. The amount of security to be exercised by the Army to protect the operations was an important item. The export of emeralds accounted for more than half of the value of mineral exports from Colombia up to the time of the mine closures.

Israel.—The growth in the imports and exports of gem stones, particularly diamond, has been explosive. The main reasons have been the continual turmoil in exchange rates, and worldwide inflation. People are actively seeking a reliable item of value and a hedge against inflation. Gem stones, most of all diamond, fill the need. The following tabulation indicates the growth pattern: [14]

Year	Net imports of rough gem diamond		Net exports of polished diamond	
	Carats	Value	Carats	Value
1970	3,624,027	$154,361,873	1,501,265	$202,040,738
1971	5,292,715	224,065,256	1,874,685	265,269,576
1972	6,176,605	316,059,884	2,296,829	385,691,783
1973	6,587,698	448,020,973	2,445,092	556,754,004

The value of diamond exports to the United States increased 78% from $74 million in 1971 to $132 million in 1973; however, the share of the exports to the United States decreased from 28% in 1971 to 24% in 1973. After the United States, Japan, Hong Kong, the Netherlands, Switzerland, Belgium, and West Germany, in that order, were the major recipients of diamond exports for 1971 through 1973. In September 1973, diamond enterprises numbered 649 and the employees numbered 9,857.

Lesotho.—As part of a continuing effort by the Lesotho National Development Corp. (LNDC) to revive commercial interest in diamond mining, De Beers Consolidated Mines, Ltd., was granted permission to conduct a 6-month evaluation of the Letseng-la-Terai diamond pipe in the Mokhotlong District.[15] This site was abandoned by Rio Tinto Zinc Corp. in 1972,

[11] Fish, R. H. East and West Meet at B. C. Jade Mine. Northern Miner, v. 59, No. 37, Nov. 29, 1973, p. 44.

[12] Northern Miner (Toronto). Cominco to Mine Diamonds in Central African Republic. V. 59, No. 37, Nov. 29, 1973, p. 32.

[13] Translations on Africa. Central African Republic. 1972 Mining Statistics Show Diamond Production Recovering. JPRS July 23, 1973. No. 1340. p. 1.

[14] Israel, State of. Annual Report for the Year 1973. Ministry of Commerce & Industry, Diamond Department, February 1974, 27 pp.

[15] U.S. Bureau of Mines. Diamond: Lesotho. Mineral Trade Notes, v. 70, No. 9, September 1973, p. 5.

and Newmont Mining Corp. cancelled a similar effort earlier this year at Kao in the Butha Buthe District. However, subsequent evaluations made of the stones in those areas have shown the diamond to be of higher value than originally appraised.

Sierra Leone.—Diamond exports continued to be the main source of revenue for Sierra Leone for 1972 and 1973. World prices which began rising in 1972 were still rising in 1973. The National Diamond Mining Corp. (DIMINCO) increased its work force to recover as much diamond as possible from its alluvial deposits. Diamond production was not tied to long-term price contracts as were other minerals, therefore revenue to the Government of Sierra Leone increased as diamond prices increased.

Sri Lanka.—The State Gem Corp., a Government-owned company, introduced an incentive program to encourage marketing of privately held gem materials. The incentive program was so successful that receipts to the Government increased more than twentyfold for the period January–July 1973 compared with those of the similar period in 1972. Many lovely gem stones are produced in Sri Lanka, but worldwide high prices applied at the source by the State Gem Corp. discouraged buyers from the United States.[16]

South Africa, Republic of.—The Central Selling Organization reported 1973 diamond sales of $1,290 million, an increase

[16] Pough, F. H. Ceylon: Island of Gems. Jewelers' Circular-Keystone, v. 144, No. 5, February 1974, pp. 77–79.

Table 3.—Diamond (natural): World production, by country [1]

(Thousand carats)

Country	1971			1972			1973 p		
	Gem	Industrial	Total	Gem	Industrial	Total	Gem	Industrial	Total
Africa:									
Angola	1,810	603	2,413	1,616	539	2,155	1,594	531	2,125
Botswana	82	740	822	360	2,043	2,403	362	2,054	2,416
Central African Republic	r 304	r 164	r 468	346	178	524	251	129	380
Ghana	256	2,306	2,562	266	2,393	2,659	232	2,085	2,317
Guinea e	22	52	74	25	55	80	25	55	80
Ivory Coast	130	196	326	134	200	334	120	180	300
Lesotho [2]	1	6	7	1	8	9	1	9	e 10
Liberia	[3] 532	[3] 277	[3] 809	[3] 414	[3] 350	[3] 764	450	370	e 820
Sierra Leone	r 778	r 1,168	r 1,946	720	1,080	1,800	[4] 670	[4] 1,000	e [4] 1,670
South Africa, Republic of:									
Premier mine	609	1,828	2,437	613	1,841	2,454	625	1,876	2,501
Other de Beers Co. [5]	2,162	1,769	3,931	2,289	1,872	4,161	2,368	1,938	4,306
Other	398	265	663	468	312	780	455	303	758
Total	3,169	3,862	7,031	3,370	4,025	7,395	3,448	4,117	7,565
South West Africa, Territory of	1,566	82	1,648	1,516	80	1,596	1,520	80	1,600
Tanzania	419	418	837	[4] 326	[4] 325	[4] 651	290	290	e 580
Zaire	r 1,274	r 11,469	r 12,743	1,339	12,051	13,390	1,294	11,646	12,940
Other areas:									
Brazil e	150	150	300	155	155	310	160	160	320
Guyana	19	29	48	20	29	49	21	31	e 52
India	16	3	19	17	3	20	18	3	21
Indonesia e	12	3	15	12	3	15	12	3	15
U.S.S.R. e	1,800	7,000	8,800	1,850	7,350	9,200	1,900	7,600	9,500
Venezuela	114	385	499	141	315	456	241	537	778
World total	r 12,454	r 28,913	r 41,367	12,628	31,182	43,810	12,609	30,880	43,489

e Estimate. p Preliminary. r Revised.

[1] Total (gem plus industrial) diamond output for each country is actually reported except where indicated to be an estimate by footnote. In contrast, the detailed separate reporting of gem diamond and industrial diamond represents Bureau of Mines estimates in the case of all countries except Lesotho (1971 and 1972), Liberia (1971 and 1972), and Venezuela (1971 and 1972), where sources give both total output and detail. The estimated distribution of total output between gem and industrial diamond is conjectural in the case of a number of countries, based on unofficial information of varying reliability.

[2] Exports of diamond originating in Lesotho; excludes stones imported for cutting and subsequently reexported.

[3] Exports for year ending August 31 of that stated.

[4] Exports.

[5] All company output from the Republic of South Africa except for that from the Premier mine; also excludes company output from the Territory of South West Africa and from Botswana.

of 40% over those of 1972. No breakdown of quantity of gem stones or value of gem stones versus the quantity and value of industrial stones was given. De Beers suspended operations at some mines in favor of operations at other mines to adjust production to meet demand.[17] Consumer demand worldwide in 1973 was mostly for 1.0 carat stones and resulted in a surplus of small stones weighing less than 1/4 carat. A marketing program was developed for use of smaller stones to accentuate other gem stones in jewelry settings.

Zaire.—On November 30, 1973, the Government of Zaire announced that companies formerly operated by a Belgian group, FORMINIERE, would be taken over 100%. Included in this group was the diamond mine of the Société Minière de Bakwanga (MIBA) located at Mbuji Mayi, East Kasai Region. The MIBA mine produces over 12 million carats of diamond annually, nearly all industrial diamond, and is a major foreign exchange earner for Zaire. MIBA employed about 4,000 workers in East Kasai in 1973.

TECHNOLOGY

The Diamond Grading Laboratory, London, England, developed a method for positive identification of individual diamond gems.[18] The method utilizes the range of color in diamond, approximately 1,000 hues, and the characteristics of flaws and inclusions commonly found in all diamond. A full "fingerprint" dossier, including a color photograph, was recommended for all stones 1 carat and over, for an approximate cost of $75 each.

Another utilization of diamond characteristics was developed for identifying the source, or area in the world, from which a diamond came. The De Beers Diamond Research Center, Johannesburg, Republic of South Africa, compiled a set of 150,000 physical observations of diamond from various parts of the world for use in establishing the identifying traits.[19]

Geologists have believed that high pressures and temperatures were necessary for the growth of diamond. Laboratory efforts using high pressure and temperatures were proven successful, first by General Electric Co. research workers and subsequently by many others. However, a review of all available data disclosed that other conditions may foster the growth of diamond.[20] Information gained from patent literature and from laboratory experiments was used to present a new theory on the growth of both natural and synthetic diamond. According to the theory, the essential requirement is a set of conditions that will provide a source of individual carbon atoms that exist in excited states. This theory attempts to explain why diamond is not present in the lower regions of kimberlite pipes, and why some kimberlite pipes have no diamond present. Although high pressure and high temperature used by the earlier experimenters provided a set of conditions that presented carbon atoms in an excited state, the passage of an electric current in the presence of catalytic contaminants was needed to complete the transformation to diamond.

Nephrite jade has a hardness of 6½ on the Mohs' scale and jadeite jade has a hardness of 7. However, the hardness is not an indication of the toughness, or the resistance to breakage. In addition to the two jades, a number of minerals were measured for relative toughness even though no widely accepted scale exists.[21] For comparison, carbonado diamond was found to be the toughest mineral. Of all other natural minerals, nephrite jade measured highest in resistance to breakage, and jadeite was ranked next, a sequence which is the reverse of their accepted relative hardness. In fact, the two jades exceeded most commercially available ceramics. Only ultrahigh strength, hot-pressed oxides and nitrides used for cutting tools and turbine vanes exceeded the two jades in toughness.

The most attractive of current imitation diamonds is a well-made doublet

[17] Forbes. De Beers. V. 112, No. 2, July 15, 1973, pp. 62–64.
[18] Black, S. Diamond: Position Secure As Queen of the Gems. The Financial Times, London. No. 25,968, Feb. 7, 1973, pp. 18–19.
[19] De Beers Consolidated Mines Limited. 1973 Annual Report. P. 23.
[20] Wilson, W. D. On the Growth of Diamond, Part I–A–Modern Theory. Lapidary J., v. 27, No. 6, September 1973, pp. 982–984. On the Growth of Diamond, Part II–Growth of Diamond at Low Pressure. Lapidary J., v. 27, No. 7, October 1973, pp. 1096–1098.
[21] Bradt, R. C., J. V. Biggers, and R. C. Newnham. The Toughness of Jade. Am. Mineralogist, v. 58, Nos. 7–8, July–August 1973, pp. 727–732.

which combines the virtues of two synthetics.[22] A sapphire crown provides durability to the exposed area, and a strontium titanate pavillion provides fire and brilliance. The juncture may be at the girdle or it may be just below the girdle. The plastic cement used to join the crown and pavillion is resistant to almost anything likely to be encountered except steam cleaning.

All phases of faceting require equipment to be properly prepared and also require a skillful artisan. The proper procedure for dopping gems for facet cutting was described for a variety of minerals.[23]

The term "cameo" applies particularly to a stone, shell, glass or other hard substance upon which a design has been carved. A comparison was made of methods used to carve antique cameos and current methods are thoroughly illustrated by examples in color photography.[24]

Pierre Gilson, one of the leading producers of synthetic emeralds, submitted a 3.5-carat synthetic black opal to the Gemological Institute of America for examination.[25] The specimen was described as "absolutely beautiful." The representatives of Gilson claimed that stones as large as 20 carats may be available in the future.

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[22] Pough, F. H. The Simulated Diamond Story. Jewelers' Circular-Keystone, v. 163, No. 10, July 1973, pp. 146, 162–170.

[23] Grieger, J. Faceting Know-How. Grieger J., v. 1, No. 2, May 1973, pp. 1, 11.

[24] Williams, J. D. Cameos. Miner. Digest, v. 2, 2d. Quarter, 1973, pp. 42–51.

[25] Jewelers' Circular-Keystone. Gilson's New Triumph. V. 144, No. 2, November 1973, p. 91.

Gold

By J. M. West [1]

Gold reached a record selling price on U.S. markets of $126.45 per troy ounce about midyear 1973. The price might have been even higher but was held to that level by Federal Government ceilings imposed as a part of economic control measures. From the beginning of the year to yearend gold prices rose $47.20 per ounce, and the average price for the year was up 67%. The official gold price was increased from $38 to $42.22 per ounce by Public Law 93–110, enacted September 21, 1973; however, no gold was exchanged at official prices and U.S. official gold reserves remained at the same quantitative level throughout the year.

Domestic gold production during 1973 declined for the third straight year, dropping 20% to 1.18 million ounces. The leading four producers, Homestake Mining Co., Kennecott Copper Corp., Carlin Gold Mining Co., and Cortez Gold Mines, accounted for nearly 75% of all U.S. gold production. Of the four, Homestake Mining operated the only underground mine; the others were open pit. Virtually all of the Kennecott gold was a copper refinery byproduct from ores of its Utah Copper Division mine (Bingham pit). The Carlin and Cortez operations in Nevada produced gold from ores in part carbonaceous, and containing "submicron" gold particles. At most gold-producing mines the gold was a byproduct. Of the 25 leading mines, 19 were mined principally for metals other than gold. The other six mines were operated for gold alone; of these, five were classified as lode-gold or gold-silver mines, and one was a placer operation in Alaska. The leading gold producers were located in nine Western States: South Dakota, Utah, Nevada, Arizona, Colorado, Washington, Montana, New Mexico, and Alaska. Minor production also came from California, Idaho, Oregon, and Tennessee.

Consumption of gold in the United States declined 8% in 1973, with jewelry and arts accounting for 52% of the total consumed. The quantity of net imports dropped 82%; however, an additional source of industry supply was established through the sale of foreign stocks on deposit at the Federal Reserve Bank in New York, and 25% of consumption came from this source during the year. Industry stocks rose 2% during the year.

World gold output declined again in 1973, dropping 3.7% to 43 million ounces. The Republic of South Africa supplied 64% of the world production, about the same proportion as in 1972. The U.S.S.R. ranked second in production and supplied 16% of the world's output, several percent higher than in 1972. Canada and the United States were third and fourth in order. Past and future world demands for gold were reviewed, and higher gold prices were predicted.[2]

Legislation and Government Programs.—A bill devaluing the dollar by 10% in terms of gold was signed into law September 21, 1973 (Public Law 93–110). The devaluation increased the value of gold reserves in the Treasury by 11.11% to $42.22 per ounce. Included in the bill was a provision giving the President discretion to eliminate regulations on private ownership of gold when this would not adversely affect the U.S. international monetary position. The International Monetary Fund (IMF) was notified of the U.S. devaluation effective at 12:01 a.m., October 18, 1973.

The Office of Domestic Gold and Silver Operations, Department of the Treasury, issued the following notice pertaining to gold coins, effective December 17, 1973:

> All foreign gold coins minted 1934 through 1959, if genuine and of legal issue, are now considered to be of such

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[1] Physical scientist, Division of Nonferrous Metals—Mineral Supply.

[2] Van Tassel, R. C., and C. Michalopoulos. The Commercial Demand For Gold in the Rest of the World. Min. Eng., v. 26, No. 3, March 1974, pp. 28–32.

Table 1.—Salient gold statistics

	1969	1970	1971	1972	1973
United States:					
Mine production ---thousand troy ounces--	1,733	1,743	1,495	1,450	1,176
Value ---thousands--	$71,944	$63,439	$61,673	$84,967	$115,000
Ore (dry and siliceous) produced:					
Gold ore ---thousand short tons--	3,393	r 3,687	r 3,471	r 3,316	4,715
Gold-silver ore ---do----	208	r 214	r 167	r 173	124
Silver ore ---do----	655	r 719	574	r 355	370
Percentage derived from—					
Dry and siliceous ores ---	59	r 61	60	58	52
Base-metal ores ---	40	r 37	39	41	47
Placers ---	1	2	1	1	1
Refinery production [1] ---thousand troy ounces--	1,717	NA	NA	NA	1,322
Exports [2] ---do----	338	1,074	1,339	1,472	2,985
Imports, general [2] ---do----	5,861	6,652	7,201	6,126	3,845
Stocks Dec. 31:					
Monetary [3] ---millions--	$11,859	$11,072	$10,206	$10,487	$11,652
Industrial ---thousand troy ounces--	4,158	3,984	4,375	4,407	4,498
Consumption in industry and the arts ---do----	7,109	5,973	6,933	7,285	6,729
Price [4] average per troy ounce ---	$41.51	$36.41	$41.25	$58.60	$97.81
World:					
Production ---thousand troy ounces--	46,612	47,522	r 46,495	r 44,718	43,070
Official reserves [5] ---millions--	$41,010	$41,275	$44,742	$45,000	$49,850

r Revised. NA Not available.
[1] From domestic ores—U.S. Department of the Treasury.
[2] Excludes coinage.
[3] Includes gold in Exchange Stabilization Fund.
[4] Engelhard selling quotations.
[5] Held by free world central banks and governments; gold valued at $35 per troy ounce in 1969–70, $38 per ounce in 1971–72, and $42.22 per ounce in 1973.

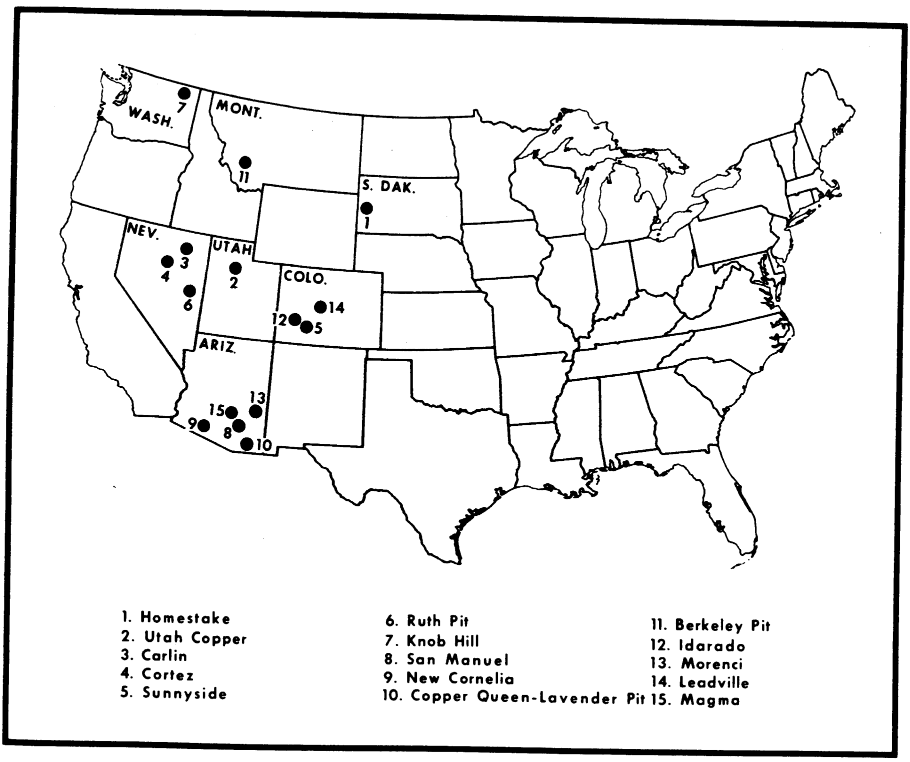

Figure 1.—Major U.S. gold-producing mines.

recognized special value to collectors of rare and unusual coins as to warrant the issuance of a general license for their importation into the United States under section 54.20(e) of the Gold Regulations for numismatic purposes. Genuine gold coins minted prior to 1934 may be imported without a license under section 54.20(d). As provided in section 54.20(e) of the Gold Regulations, modern gold coins minted after 1959 will continue to be prohibited importation into the United States and such coins may not be held outside the United States by persons subject to U.S. jurisdiction.

Under section 54.24(b)3(ii) of the Gold Regulations, gold coins made subsequent to 1933 may be exported from the United States only under license of form TGL–11 issued by the Director, Office of Domestic Gold and Silver Operations.

Gold coins contained in jewelry items are subject to the same regulations which govern the importation/exportation of unmounted gold coins.

Domestic selling prices for gold were frozen on June 13, 1973, and the ceilings established were to be effective for a maximum of 2 months. A base period of June 1–8, 1973, was selected and the ceiling established for each company was at the highest price level at which 10% or more of its sales were made during the base period. The general price freeze lasted through August 13. Controls were also placed on gold products but these were later modified in specific instances by the Cost of Living Council so increased material costs could be passed on to buyers by fabricators who were caught in the middle of the cost-price squeeze.

On November 13, 1973, the two-tier gold price system was terminated by consensus of officials of the seven nations that had initiated the system March 17, 1968. Under the system, the United States and six other nations (the London Gold Pool) had agreed not to sell reserve gold to private parties, nor to buy gold directly from the Republic of South Africa or on the free market. In December, following the system's termination, the IMF and the Republic of South Africa terminated a 1969 gold agreement whereby the IMF would purchase gold from South Africa whenever the price fell below the $35 per ounce official level or whenever South Africa had a payments deficit. No gold had been purchased under the agreement since August 1971.

The Office of Minerals Exploration (OME), U.S. Geological Survey, continued its program of participitory loans for gold exploration covering up to 75% of approved costs. A small number of active contracts were in effect in several Western States.

DOMESTIC PRODUCTION

The drop in domestic gold output during 1973 resulted largely from a phaseout of production at the Cortez mine, Lander County, Nev., the mining of lower grade ores and a 20-day strike at the Carlin mine, Eureka County, Nev., and the mining of lower grade ores at the Homestake mine in Lead, S. Dak. Despite the reduced outputs, gold mining operations were generally more profitable owing to the sharp rise in gold prices during the year. Utah production was down mainly because the Mayflower mine, in the Park City district of Utah, had ceased operations the year before. In Washington, production was lower because the Knob Hill mine produced less from declining reserves. The Knob Hill mine with its 250-ton-per-day mill was expected to close about the end of 1975 unless additional exploration was productive.[3] In Alaska expansions were underway and a revival of gold mining was predicted.[4] Standard Metals Corp. increased ore reserves by core drilling at its Silverton mine in Colorado.[5] Exploration and development activities were reported at a number of California mines.[6] The Cripple Creek, Colorado, district, one of the large past producers of gold, was undergoing renewed development.[7]

Of the total domestic gold produced in 1973, the top 4 producers provided 75% and the 25 leading producers supplied 98%. Placer production accounted for only about 1% as before. Approximately 47% of pro-

[3] Mining Record (Denver). Higher Gold Prices Increase Life of Washington Gold Mine. V. 84, No. 26, June 27, 1973, p. 5.

[4] ———. Gold Mining Revival Foreseen in Alaska. V. 84, No. 19, May 9, 1973, p. 2.

[5] American Metal Market. Standard Metals' Reserves Bolstered With Discovery of New Silverton Ore. V. 81, No. 14, Jan. 14, 1974, p. 30.

[6] California Division of Mines and Geology. Gold Mines—Activity Reported in 1972-1973, Calif. Geol., v. 26, No. 12, December 1973, pp. 296–298.

[7] World Mining. Cripple Creek's Golden Glamour. V. 26, No. 5, May 1973, pp. 46-48.

duction was a byproduct of mining for other metals. An estimated 1.8 million ounces of secondary gold was treated by refiners, compared with 2.1 million ounces in 1972. Among the largest gold refiners were American Metal Climax, Inc., which reported refinery output of 820,000 ounces in 1973, slightly lower than in 1972, and Kennecott Copper Corp. with 342,284 ounces refined in 1973 versus 350,080 ounces in 1972.

At the Homestake Mining Co. operations, production dropped 12% to 357,634 ounces in 1973. The average price received on sales was $93.36 per ounce, 65% higher than in 1972. The average recovered grade was 0.227 ounce per ton in 1973, compared with 0.278 ounce in 1972, an 18% drop. A total of 1.57 million tons of ore was milled, up 7%; revenues from gold sales, which included gold purchased for resale, were $52.05 million, 55% higher than in 1972. Metallurgical recovery improved following startup of a new "charcoal-in-pulp" treatment plant for handling the slime fraction of the ground ore; recovery averaged 93.63% for the year, and reached 94.6% in December. A shortage of skilled miners continued to hamper production. A contract was let to sink the new No. 7 winze and deepen the No. 8 shaft from the 7,200- to the 8,000-foot level. A major crosscut was being driven on the 5,300-foot level to explore new ground. Several large-tonnage blasthole stopes were prepared for extraction of lower grade ore. This mining method dilutes the ore but provides greater tonnage per man-shift. Ore reserves were estimated at 9.05 million tons proven, averaging 0.249 ounce per ton, a 24% increase in tonnage but a 17% decrease in grade from 1972. Proven reserves included 1.89 million tons averaging 0.148 ounce per ton in blasthole stopes. Additional reserves totaled 6.8 million tons at a grade slightly over 0.3 ounce per ton.

The Carlin mine, Eureka County, Nev., produced 150,000 ounces of gold, compared with 194,000 ounces in 1972, a 23% decline. Sales were valued at $15.0 million, compared with $11.7 million in 1972. Despite less production, net income from the Carlin operations rose 47% to nearly $5.7 million. Waste removal began at the Bootstrap property, where about 50,000 tons of low-grade ore was stockpiled for heap leaching. Other ores were stockpiled to haul to the Carlin mill, 12 miles away. Five miles from the mill the Blue Star property was being drilled. Reserves at the two properties totaled 1.9 million tons, averaging 0.14 ounce per ton. At the Carlin mine reserves amounted to 2.4 million tons averaging 0.319 ounce per ton at the end of 1973. Exploration of areas surrounding the open pit workings and at depth was continuing.

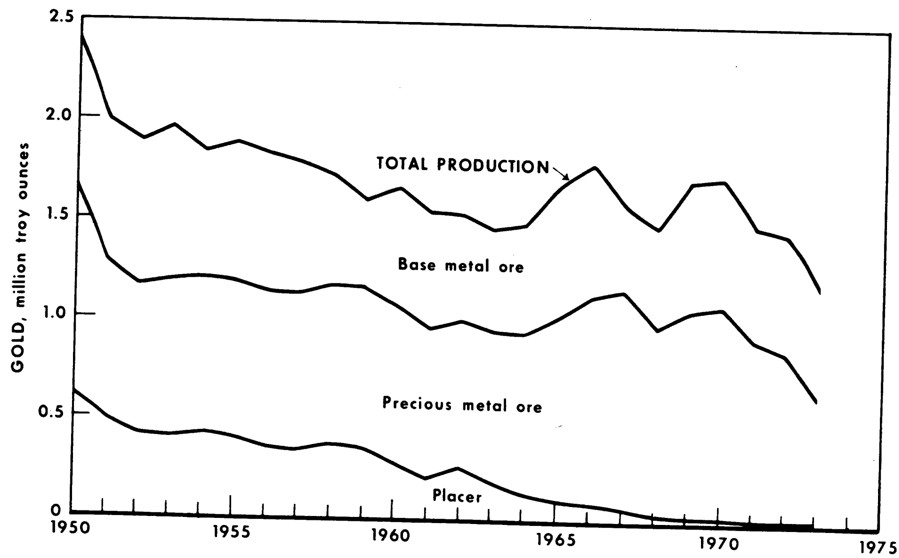

Figure 2.—Sources of U.S. gold production.

At the Cortez mine, Lander County, Nev., mill throughput declined 5% to 762,500 tons in 1973. Production dropped 60% to 75,700 ounces of gold, compared with 190,-600 ounces in 1972. The average grade of ore milled dropped to 0.109 ounce per ton, compared with 0.214 ounce in 1972, and 85.6% of the gold was recovered. Milling of ore from the nearby Gold Acres property began at the Cortez mill in April, and 643,400 tons of ore, over half of the property's reserves, were treated before yearend. The balance of the mill feed came from marginal ores in the Cortez mine. Also in 1973 1.16 million tons of low-grade ores were added to heap leach piles, compared with 0.82 million tons placed in 1972. Gold (included in totals) produced from heap leaching amounted to 10,300 ounces, compared with 37,600 ounces in 1972. At yearend, 1.09 million tons was under leach treatment (which began in October) at the Gold Acres property. Gold Acres was expected to be mined out by the end of 1974.

UV Industries, Inc., formed a new subsidiary, Alaska Gold Co., to manage its gold properties in Alaska and Arizona. During 1973 the firm operated a gold dredge at Hogatza, Alaska, and tested new drilling equipment for thawing operations at Nome, Alaska. From 1974 to 1976, it was planned to activate two dredges in the Nome area where extensive reserves were believed to exist.

The Golden Cycle Gold Corp. continued exploration of its properties and rehabilitation of its 1,000-ton-per-day mill in the Cripple Creek district of Colorado. The mill was last operated in early 1962. According to plans, local dump tailings would be milled pending the start of deep mining scheduled in 1975. Standard Metals Corp. operated its 700-ton-per-day mill at Silverton, Colo., on three shifts and remained Colorado's largest gold producer. About 40% to 45% of its smelter returns were in gold in 1973, and its Sunnyside mine reserves were adequate for 4 to 5 additional years. Many other gold mines throughout the West were explored during the year in anticipation of reopening.

CONSUMPTION AND USES

Domestic consumption of gold, as reported by the Office of Domestic Gold and Silver Operations, U.S. Department of the Treasury, declined 8% to 6.7 million ounces in 1973. Consumption in 1973, according to surveys of fabricators of industrial and other products, was divided, as follows, in thousand ounces (with 1972 figures for comparison): Jewelry and arts, 3,473 (4,344); dental, 679 (750); and industrial, including space and defense, 2,577 (2,191). Increases in the last category were attributed to growing electrical and electronic consumption, which comprises the bulk of this category. Jewelry and dental uses were down owing to consumer resistance to higher gold prices, which were passed on in product prices. Figure 3 shows consumption trends in recent years.

In a study done for the Federal Bureau of Mines, an assessment was made of how much gold would be required for U.S. industry through 1978 based on a variety of data for past years.[8] A general downtrend in consumption was forecast at gold prices of $70 and over per ounce. During 1973, demand for gold coins increased sharply, and supplies in the hands of coin dealers fell short. U.S. coin buyers continued to be limited by Treasury regulations governing purchases, although rules were eased, as noted under Legislation and Government Programs. Purchases of gold coins in 1973 were estimated to have reached a value of $125 million.

In product development, more efficient use of gold was obtained with a clad strip in the form of a tape, which could be attached or welded to electrical contacts.[9] A gold-clad wire was also developed for electrical use utilizing a molecular bonding technique. Growing use of electroplated gold and other precious metal contacts was cited. Several new low-alloy gold electroplating processes were introduced for use on printed circuit boards, contacts, switches,

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[8] Van Tassel, R. C., and C. Michalopoulos. The Commercial Demand For Gold in the United States. BuMines Open File Rept., 1973, 63 pp., available for consultation at the Bureau of Mines Library at Pittsburgh, Pa., Denver, Colo., Spokane, Wash., and Juneau, Alaska; at the Central Library, U.S. Department of the Interior, Washington, D.C. and from National Technical Information Service (NTIS), Springfield, Va., PB 224 789/AS.

[9] Lyman, S. V. V. How Precious Metals Cut Contact, Conductor Costs. Am. Metal Market, v. 80, No. 206, Oct. 24, 1973, pp. 1A–7A.

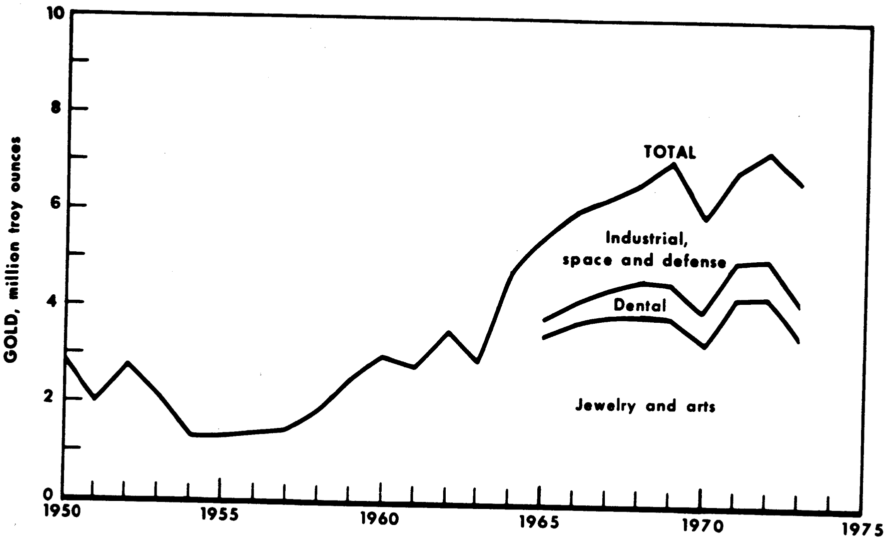

Figure 3.—Gold consumption in the United States.

and electronic parts.[10] In the electronics industry, bright tin, tin-nickel, and palladium were considered as substitutes for gold; however, the high cost of adapting processes keyed to gold was said to be keeping immediate customer interest in substituting less costly materials relatively low.[11] It was estimated that bright tin would be used increasingly in connectors, possibly replacing 10% of the gold being used for this specific purpose.[12] Research efforts of process vendors were said to be directed to developing suitable alloys of 60% to 80% gold combined with copper, cadmium, nickel, and silver. The jewelry industry was said to have used some of the new alloys extensively. One company spokesman did not expect higher gold prices to have a significant impact on the semiconductor industry, the largest single consumer of gold salts, owing to conservation steps underway.[13]

Particularly useful to the jewelry industry was a new series of acid gold-plating solutions which were said to give unvarying reproducibility of color.[14] Also, an electroless process for gold-plating over a variety of substrates was developed for use in the electronics industry.[15] Statues were gilded with a new "brush" electroplating technique,[16] thoria added to gold and platinum gave a superior product for high-temperature electrial uses,[17] and gold was readily mounted on a new vitreous carbon used in dentistry for tooth implants.[18]

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[10] Secondary Raw Materials. Sel-Rex Announces Two New Low-Alloy Gold Electroplating Processes. V. 11, No. 12, December 1973, p. 146.

[11] Bence, B. '73 Gold Usage for Parts Plating to Equal '69—Sylvania Peak Year. Am. Metal Market, v. 80, No. 236, Dec. 6, 1973, pp. 1, 5.

[12] Patton, D. Donaldson, Wallace Give Forum a 14-Karat Gold Assay: GTE Sylvania Official Says Use in Electronics Will Decline. Am. Metal Market, v. 80, No. 232, Nov. 30, 1973, pp. 1, 7.

[13] American Metal Market. Lea-Ronal's Gold Rush Is Conservative. V. 80, No. 121, June 21, 1973, p. 12.

[14] ———. New Series of Acid Gold Plating "Baths." V. 80, No. 247, Dec. 21, 1973, p. 10.

[15] ———. Engelhard Develops Goldplating Process That's Electroless. V. 80, No. 230, Nov. 28, 1973, p. 12.

[16] Bowers, E. Aerospace Technique Banishes Corrosion, Wash. Statues Brushed Glistening Clean. Am. Metal Market, v. 80, No. 72, Apr. 12, 1973, p. 6.

[17] American Metal Market. Thoria Added to Platinum, Gold Gives Unique Results. V. 80, No. 215, Nov. 6, 1973, p. 26.

[18] ———. Vitreous Carbon for Dental Use Patented. V. 80, No. 46, Mar. 7, 1973, p. 9.

STOCKS

Monetary.—Official U.S. gold stocks, including those in the Exchange Stabilization Fund, were valued at $11,652 million based on $42.22-per-ounce gold at the end of 1973, compared with $10,487 million based on $38-per-ounce gold at the end of 1972. The equivalent amount of gold at the end of 1973 was 276.0 million ounces, unchanged from a year earlier. Suspension of the convertibility of dollars to gold, begun August 15, 1971, remained in effect at yearend 1973.

Federal Reserve banks held $17,068 million (404.3 million ounces at $42.22 per ounce) worth of "earmarked" gold for foreign official accounts at the end of 1973, compared with $15,530 million (408.7 million ounces at $38 per ounce) at the end of 1972. Total gold stocks of national monetary authorities and international institutions (excluding Communist countries) were valued at $49,850 million at the end of 1973 ($42.22 per ounce), compared with $44,890 million at the end of 1972 ($38 per ounce). Stocks at the end of 1973 were virtually unchanged from a year earlier at 1,181 million ounces. U.S.S.R. gold reserves were estimated to be worth $2,715 million, equivalent to around 65 million ounces.

World monetary stocks of gold at the end of 1973 were distributed as follows, in million ounces: United States, 276.0; IMF, 153.4; West Germany, 117.6; France, 100.9; Switzerland, 83.2; Italy, 82.5; the Netherlands, 54.3; Belgium, 42.2; Portugal, 27.5; Canada, 22.0; Japan, 21.1; Republic of South Africa, 19.0; Spain, 14.3; Venezuela, 11.2; Bank for International Settlements, 5.6; others, 149.9. Compared with 1972, the greatest changes were shown in stocks of the Republic of South Africa, up 1.1 million ounces; Belgium, down 0.9 million ounces; and Portugal, up 0.6 million ounces. Also, Philippine stocks dropped 0.8 million ounces to 1.07 million ounces. "Paper gold" Special Drawing Rights (SDR's) in the IMF were valued at $10,625 million at the end of 1973. Of this value, $7,963 million was allotted to industrial countries and $1,890 million to less developed areas. U.S. reserves in the form of SDR's were valued at $2,166 million at the end of 1973, compared with $1,958 million at the end of 1972. The unit of SDR remained by definition equivalent to 0.888671 gram of fine gold. IMF dollar values were based on $38-per-ounce gold before February 1973 and on $42.22-per-ounce gold thereafter.

Industrial.—Inventories of gold at domestic refiners and fabricators rose 2% during 1973 to 4.5 million ounces, according to data collected by the Office of Domestic Gold and Silver Operations, U.S. Department of the Treasury.

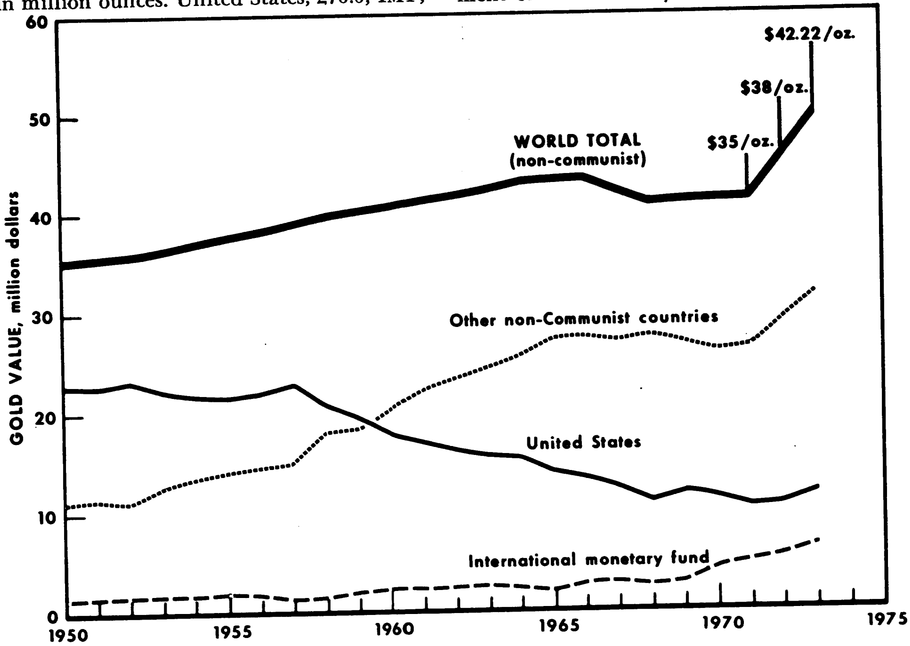

Figure 4.—World monetary gold stocks.

PRICES

During the year, free market gold prices rose from a low of $64.35 per troy ounce (Engelhard Industries selling price) to a record $126.45 about midyear, then declined. The low price was on January 18, and the high price was reached on June 5 and again on July 6 and 9. The high price was the maximum established by Phase III price ceilings, and the ceiling caused Engelhard Industries to suspend buying quotations 1 day on July 6. On January 2, the first trading day of 1973, the price was $65.55 per ounce, and on December 31, the last trading day, it was $112.75, $47.20 or 72% higher. The average price for the year was $97.81 per ounce, 67% higher than in 1972. The rise in prices was international and was generally attributed to less confidence in currency values, inflationary trends, unsettled world trade deficits, and limited supplies of new gold.

The U.S. official gold price was much lower in comparison, and remained at $38 per ounce until October 18, when it was raised to $42.22. October 18 was the date on which a September 21, 1973, devaluation law became effective (Public Law 93–110).

Table 2.—U.S. monthly gold selling prices, per ounce

(Engelhard Industries)

Month	1973		
	Average	Low	High
January	$65.59	$64.35	$66.55
February	74.67	67.05	86.95
March	84.87	80.45	90.45
April	90.96	89.70	91.70
May	102.41	90.75	115.20
June	120.61	116.00	126.45
July	120.46	114.75	126.45
August	107.10	94.50	118.00
September	103.39	100.50	106.60
October	100.58	97.25	104.25
November	95.77	90.50	102.25
December	107.37	100.75	112.75
Year	97.81	64.35	126.45

FOREIGN TRADE

Gold exports in 1973 totaled 2.99 million ounces valued at $146 million and went largely to Switzerland (69%), Uruguay (12%), the United Kingdom (7%), and Canada (6%); the balance went to seven other countries. Scrap comprised 11% of the exports, going to the United Kingdom (46%), Belgium-Luxembourg (44%), and six other countries. About 83% of the exported gold consisted of monetary metal, going to Switzerland, Canada, and Uruguay.

Total imports of 3.84 million ounces of gold were valued at $356.2 million. The bulk of the imports came from Canada (39%), Switzerland (32%), and the U.S.S.R. (21%). The balance was from 31 other countries. Virtually all imported gold was destined for industrial use. In addition to import sources, industry was supplied with 1.70 million ounces from foreign stocks on deposit at the Federal Reserve Bank, New York.

Net imports of gold showed a decline compared with those of 1972 (figure 5). The net value in 1973 was $210.2 million versus $294.6 million in 1972. The 1973 net value was not directly comparable with that of 1972, because reported exports in 1973 included a large quantity of monetary gold (2.21 million ounces), which was shipped at the lower, official monetary value. Net quantities imported in 1973 and 1972 respectively were 0.86 and 4.65 million ounces, showing a much sharper drop in net trade. The inflow of gold in ore, scrap, and base bullion was 70% of the outflow in the form of scrap.

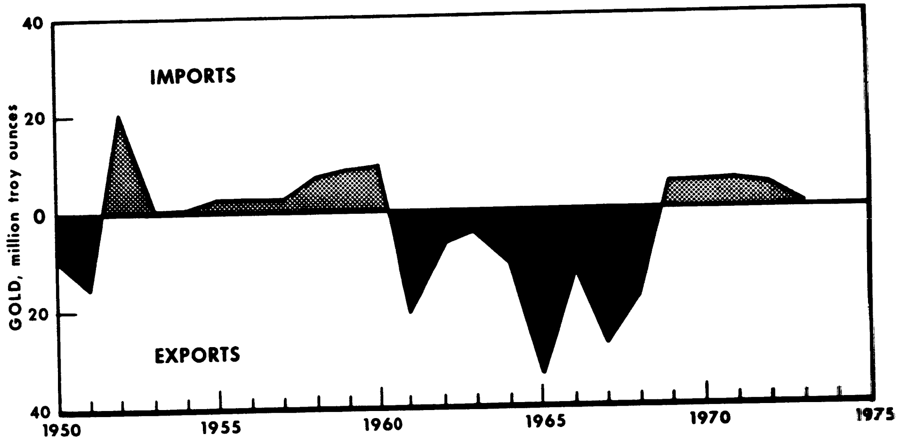

Figure 5.—Net exports or imports of gold.

WORLD REVIEW

World gold production (figure 6 and table 14) declined for the third straight year to 43.1 million ounces, a 3.7% drop. Outputs were lower in major producing countries except the U.S.S.R. where a 3% increase to 7.1 million ounces was estimated. All gold sales from the Republic of South Africa were made by the South African Government, whose selling policies had an important influence on gold markets. The bulk of South African gold was sold in Switzerland and moved from there to other markets. Quantities moving to markets were generally less in the first half of the year than in the second half. For the year, about 4% of South African production went into the Governments' reserves, and the balance was sold at free market prices. According to a major London gold trader, the total European industrial gold offtake in 1973 was 13.8 million ounces, about 2 million ounces less than in 1972. Italy remained the largest consumer with its important jewelry industry. Consumption in West Germany was estimated at 2.9 million ounces; in France consumption was believed to have increased to 1.9 million ounces, and in Spain an estimate of 1.6 million ounces was given. In addition, it was estimated that 12.5 million ounces were added to European speculators' holdings, including 3.2 million ounces to privately owned stocks in France. On balance, then, total European offtake approximately equaled total South African gold sales, and the remaining about 8 to 10 million ounces of non-Communist world production had to supply the rest of the world. U.S.S.R. sales to the free world were estimated between 6 and 9 (probably closer to 6) million ounces in 1973; as a net result, non-European countries probably received about 15 million ounces of gold, about 75% destined for industrial purposes.

Angola.—Negotiations were conducted by the Angolan Sociedade Mineira da Huila, Lda., of Sá da Bandeira to form an international consortium to explore gold deposits in the southern part of the country. Development of deposits near Chipindo was under consideration.

Australia.—Australian gold output rose sharply in 1973 responding to higher prices. Western Australia reopened its state-owned custom gold mill at Laverton early in the year. Gold Mines of Kalgoorlie, owned by Western Mining Corp. Ltd., and the Lake View and Star gold mines, owned by Poseidon Ltd., merged operations under a new company, Kalgoorlie Lake View Pty. Ltd., and planned renewed development work in Western Australia's "Golden Mile." Newmont Mining Co. reported the discovery of gold in a new area about 180 miles from the seacoast in a remote region of the Great Sandy Desert of Western Australia. Exploration and evaluation work was underway.

Bolivia.—Disputes continued in 1973 between the Bolivian Government and South

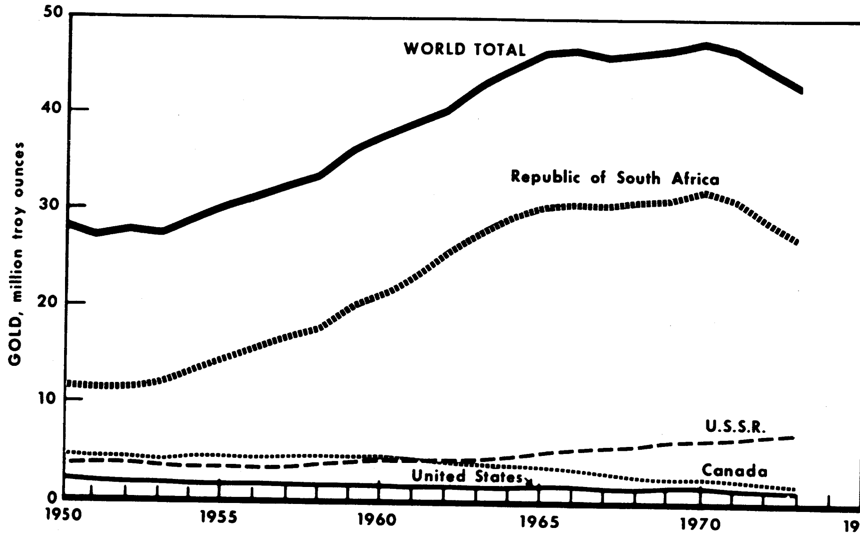

Figure 6.—World production of gold.

American Placers Inc. (United States) over whether past gold production operations in the Teoponte area had been conducted in accordance with expectations. In July, the Government issued a decree that required the U.S. firm to present within 6 months concrete work plans for mining an 11,700-hectare concession area; otherwise, the area would revert to the Government.[19] Continued placer operations on approximately 700 hectares of land would not be affected. A new law was passed regulating exploration and mining of gold in National Reserve areas.[20] A new Canadian company, Camino Gold Mines, Ltd., was formed to explore and develop an area of placer gold deposits 85 miles northeast of LaPaz in the Tipuani River valley. Test equipment was flown to the area about yearend.

Brazil.—Anglo American Corp. and several Brazilian associates entered into agreements to explore for gold in the State of Bahia. Most Brazilian production continued to come from a group of lode mines in the Nova Lima area of Minas Gerais.

Canada.—Gold production dropped 7% in 1973, continuing its long downtrend. Production value rose, however, by 55% owing to higher gold prices. Gold accounted for about 5% of Canada's metal production value and 2% of total mineral production value. Ontario remained the largest gold producing Province with 47% of the total national output, Quebec was next with 25%, and the Northwest Territories and British Columbia followed with 13% and 10%, respectively. Manitoba and Saskatchewan contributed 4% together, and less than 1% came from Newfoundland and New Brunswick. The Yukon supplied a few thousand ounces, and a few ounces were produced in Nova Scotia and in Alberta. The greatest percentage drops in production were in the Northwest Territories (18%), Ontario (12%), and Quebec (11%). Significant increases were shown in British Columbia (64%) and Manitoba (26%). Of all gold produced, quartz lode and placer mines supplied 73.6%; the balance was a byproduct from base metal mines.

In Ontario, plans to expand gold exploration and add production facilities were reported. An optimistic appraisal was made of the outlook for new gold discoveries in the Timmins-Val d'Or region of Ontario and Quebec.[21] An industry opinion survey

[19] U.S. Embassy, LaPaz, Bolivia. State Department Airgram A-165, Aug. 14, 1973, 4 pp.
[20] U.S. Bureau of Mines. Bolivia: Law Governing Gold Mining Concessions in the National Reserve. Mineral Trade Notes, v. 70, No. 12, December 1973, pp. 35-37.
[21] Mineral Resources Branch, Department of Energy, Mines and Resources, Canada. The Timmins-Val d'Or "Gold Belt" of Ontario-Quebec, Can. Min. and Met. Bull., v. 66, No. 730, February 1973, pp. 70-71.

indicated a potential for new discoveries in the area amounting to between 8 and 20 million ounces in gold content in deposits averaging about 0.25 ounce per ton of ore. Dome Mines Ltd. operated its Timmins, Ontario, mill at about full capacity of 2,000 tons per day, milling about 10% more ore at 6% lower grade than in 1972. Pamour Porcupine Mines Ltd. completed its mill expansion and operated at 2,500 tons per day beginning in March 1973. The cost of the 600-ton-per-day expansion was about $450,000. Mill feed was about 75% from the Pamour mine and 25% from the Aunor (No. 3) mine, both operated by the Noranda Group. McIntyre Porcupine Mines Ltd. continued operations at its 62-year-old mine near Timmins, milling about 900 tons per day of gold ore along with a larger tonnage of copper ores from parallel veins. Reserves of gold ore were estimated at a 2-year supply averaging 0.283 ounce per ton, and the company studied marginal ores and adjoining leased properties with the hope of expanding reserves in view of higher prices. On November 27, McIntyre Porcupine sold its Schumacher gold and copper properties to Pamour Porcupine Mines. To sale date, the 1973 production was 69,000 ounces of gold compared with 104,000 ounces for all of 1972.

In the Red Lake area, western Ontario, Dome Mines' Campbell Red Lake operation produced 196,190 ounces of gold compared with 196,855 ounces in 1972. Dickenson Mines Ltd. increased exploration at its extensive holdings in the Red Lake area and began to explore its newly acquired Rowan Gold Mines properties in Ball Township. Cochenour Wilians Gold Mines Ltd. planned to reopen its Wilmar mine, also in the Red Lake area. The deposit was believed to contain a large tonnage of ore grading 0.12 to 0.15 ounce of gold per ton, and plans were considered for a possible 1,000- to 2,000-ton-per-day milling operation. Kerr Addison Mines Ltd. maintained operations in the Larder Lake area, Eastern Ontario, at a milling rate of about 900 tons per day, its main mine at Virginiatown was estimated to have about 4 year's reserves with but little chance for additional marginal ores.

Camflo Mines Ltd. was the leading gold producer in Quebec with bullion output of 98,228 ounces in 1973, compared with 100,101 ounces in 1972. Dome Mines' Sigma Mines Ltd. was second with 78,204 ounces produced in 1973 versus 85,614 ounces in 1972. Other lode gold producers were East Malartic Mines Ltd., Lamaque Mining Co. Ltd., and Marban Gold Mines Ltd. The average grade for lode mines was 0.145 ounce per ton. In addition to 230,005 ounces from Quebec lode mines, 161,641 ounces of gold was produced from base metal mines, 40% of which was from Noranda Mines Ltd. The new $15 million gold operation of Agnico-Eagle Mines Ltd. was scheduled for production at 1,000 tons per day in late 1973. Reserves of 3 million tons averaging 0.29 ounce per ton were expected to be adequate for 10 years of production. The mine is located in Joutel Township. It was developed to the 1,800-foot level and will utilize a trackless haulage combined with sublevel bench mining method. Chibex Ltd. planned to open a mine in the Chibougamau area where ore reserves were estimated at 1.2 million tons grading 0.229 ounce per ton of gold and 0.5% copper. Equipment was being assembled for a 750-ton-per-day mill in late 1973. In Cadillac Township of northwestern Quebec, Gold Hawk Mines Ltd. continued core drilling and prepared to ship ore to a nearby mill. The property was about 17 miles from Malartic on the Noranda-Val d'Or highway. Quebec Sturgeon River Mines Ltd. prepared to mine a nearby 1-million-ton ore body averaging 0.217 ounce of gold per ton at its Batchelor Lake property in northwestern Quebec.

Cominco Ltd. planned a $5 million investment in the Con mine at Yellowknife, Northwest Territories. Mill capacity was about 500 tons per day, and ore reserves included over 1 million tons grading 0.07 ounce per ton. O'Brien Gold Mines Ltd. planned underground development at its Cullaton Lake property in the Northwest Territories, after favorable drill results. In British Columbia, Bralorne Resources Ltd. undertook a major gold exploration program at its Bralorne-Pioneer property.[22] A 200- to 300-ton-per-day operation was foreseen for the Brandywine gold-silver property 70 miles north of Vancouver, British Columbia, by its owner, Northair Mines Ltd. Home Oil Co. Ltd. and Mosquito Creek Gold Mining Co. Ltd. joined to explore and develop gold claims in the Wells-Barkerville area, British Columbia. Kennco Explorations Ltd., a subsidiary of

[22] Western Miner. Bralorne Reborn. V. 46, No. 8, August 1973, pp. 24–25.

Kennecott Copper Corp., continued exploring newly found gold-silver veins averaging 10 feet in width in the Toodoggone area, 170 miles north of Smithers, British Columbia.

Colombia.—Pato Consolidated Gold Dredging Ltd. reported 1972 production at 63,104 ounces of gold from 17.9 million cubic yards of material at its operations near Bagre in Northeast Antioquia, and 1973 output was expected to be higher. A fifth dredge, planned to go into operation in 1974, was expected to increase production about 18%. Proven reserves were estimated to be adequate for continued full-time operations for the next 15 to 20 years. Cia. Minera Chocó Pacifico operated five dredges in the San Juan River basin, near Andagoya, in the Department of Chocó, northwest Colombia, producing gold and platinum. From 1966 to 1971, an estimated 1.1 million ounces of platinum and 2.4 million ounces of gold were produced from 700 million cubic yards of material mined from the Chocó deposits. Output in 1973 was estimated at 9,000 to 10,000 ounces of platinum and about twice that amount of gold. Most of the balance of Colombian gold and platinum production came from operations of Cia. Minera Frontino Gold Mines, with properties in the Department of Narino. During 1973, the Colombian Government took steps that could lead to possible expropriation of foreign company mining rights and properties.[23]

Costa Rica.—Cia. Minera del Guanacaste, which opened the Tres Hermanos gold mine in the Abangares area in April 1972, expanded milling capacity by addition of a 50-ton-per-day ball mill and flotation cells to a stamp mill equipped with two, five-stamp batteries and amalgamation tables. The Bulora Corp. (Canada) reopened the El Libano gold mine near Tilaran and began construction of a 100-ton-per-day cyanide mill to be operative by March 1974.[24] Mining costs at the El Libano were estimated at $15 to $17 per ton of ore, and inferred and indicated reserves totaled about 161,000 tons grading 0.84 ounce of gold and 0.88 ounce of silver per ton.

Dominican Republic.—Gold and silver production was scheduled to begin about yearend 1974 from the Pueblo Viejo mine, under development northwest of Santo Domingo by Rosario Resources Corp. Plant construction costs were expected to exceed $24 million, and planned milling capacity was revised upward from 6,000 to 8,000 tons per day. When fully operating, the mill was expected to produce 350,000 ounces of gold and 1.5 million ounces of silver annually in the form of doré bullion to be refined elsewhere. Ore reserves were increased 50% during the year to 30 million tons as a result of further studies.

El Salvador.—Production was planned by San Sebastian Gold Mines, Inc. (United States) at a rate of 100 tons per day at the company's leased property near Santa Rose de Lima. The mine was scheduled to produce at a rate of 1,200 ounces of gold per month after startup, planned in March 1974. Other deposits in the eastern portion of El Salvador were said to have potential.[25]

Ethiopia.—Virtually all production continued to come from the Government-operated Adola gold mine, a placer producing 20,000 to 30,000 ounces of gold annually; a minor quantity of platinum was produced with gold at the Government Yubdo mine.

France.—The source of most French production, Mines de Salsigne, was slated to change ownership through an agreement to purchase control by two Canadian firms, New Calumet Mines Ltd. and Jorex Ltd. The mine, located near Carcassonne in southern France, produced at a rate of 170,000 tons of ore annually, with resulting output of about 66,000 ounces of gold, 170,000 ounces of silver, 385 short tons of copper, 60 tons of bismuth and arsenic, and sulfuric acid byproducts. Other gold concessions in the Limoges area of central France were included in the agreement. Salsigne ore reserves were estimated at 2.8 million tons averaging 0.38 ounce and 1.34 ounces per ton, respectively, of gold and silver.

Ghana.—The Ghanaian Government continued to control sales of gold and during the year proposed an export duty equivalent to about $2.10 per troy ounce after the first 100,000 fine ounces. The Ashanti goldfields area was the source of most Ghanaian production, with sales mainly in Switzerland. Interest was revived in establishing a gold refinery at Tarkwa.

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[23] Engineering and Mining Journal. Three Gold Mines Face Nationalization in Colombia. V. 174, No. 9, September 1973, p. 24.

[24] Northern Miner (Toronto). Canadian Firm Developing Gold Mine in Costa Rica. V. 59, No. 23, Aug. 23, 1973, pp. 1, 6.

[25] U.S. Embassy, San Salvador, El Salvador. State Department Airgram A-166, Nov. 27, 1973, 2 pp.

Honduras.—Rosario Resources Corp. reopened its silver-gold mine at San Juancito and planned gold placer operations in the Mosquitia area of Honduras.

India.—Production in 1973 was slightly higher than in 1972. The Government in April 1972 consolidated its two gold-mining companies, the Kolar and Hutti, into one organization, the Bharat Gold Mines, Ltd., hoping this would encourage modernization and greater efficiency. Annual subsidies of $5.6 million were provided in new budget estimates to offset operating losses. The Kolar mines produced 67,997 ounces of gold in 1972; the Hutti mine produced 37,776 ounces. Average ore grades were 0.17 to 0.18 ounces per ton, respectively. Combined ore reserves were estimated at 4.2 million tons averaging 0.27 ounce per ton, with most of the remaining accessible ore in the Champion Reef at depths in excess of 10,000 feet.[26]

Japan.—Beginning April 1, 1973, all restrictions and duties on the import of gold ingot were removed, and on July 1 restrictions on importing gold products were also removed, although a 20% duty remained. The action stemmed from rapidly expanding Japanese industrial demand and declining production capabilities. Plans were announced by Sumitomo Metal Mining Co. to close its formerly important Konomai gold mine in Hokkaido because of high costs. Output was down to about 10,000 ounces per year.

Mexico.—The Mexican Comisión de Fomento Minero joined with a U.S. firm to explore the possibly large Loma Bonita gold placer in southern Mexico. The Government organization received options and a 20% equity as part of the agreement. The new discovery was believed to be in the State of Guanajuato.

Nicaragua.—Rosario Resources Corp. purchased the Nicaraguan properties and assets of La Luz Mines Ltd. and planned to reactivate gold operations at Siuna, where they were suspended in 1968. An extensive exploration program was planned to develop additional reserves. The purchase included the Rosita copper mine, which has been a consistent source of byproduct gold, supplying about 17,000 ounces in 1970–71.[27]

Panama.—Copper and gold exploration and extraction concessions were offered by the Government in the Río Pito area of Panama. The deposits, originally discovered during a United Nations study, were located in an isolated area on the Caribbean side of Panama in the San Blas region near the Colombian border. Under a new draft of the Minerals Resources Code, requests for exploration concessions were to be accompanied by a $100 payment and those for extraction concessions by a $500 payment. Bison Petroleum & Minerals Ltd. and Pavonia S. A., a subsidiary of Canadian Javelin Ltd., obtained a large concession, which included the El Remance gold deposit estimated to contain 115,000 tons of ore averaging from 0.25 to 0.33 ounce of gold per ton.

Papua-New Guinea, Territory of.—Byproduct gold production at the Bougainville copper mine exceeded expectations. From the second to the fourth quarters 1972, grades increased from 0.019 ounce of gold per ton and 0.67% copper to 0.034 ounce of gold per ton and 0.86% copper. Tonnages produced in 1973 were above forecast rates. Plans were announced by Kimberley Securities Ltd., Rumble Explorations Pty. Ltd., and Mt. Isa Mines Ltd. for a joint gold placer operation of Porgera, New Guinea. Reserves in two areas were estimated at 2.25 million cubic yards averaging 0.0175 ounce of fine gold per yard (April) and 120,000 cubic yards averaging 0.125 ounce per yard (Denys Creek). A 3- to 5-year mining operation was envisaged. Lode deposits were also studied. New Guinea Goldfields, Ltd., continued open pit operations in Papua-New Guinea, treating about 7,000 tons of ore monthly at its Golden Ridges mill. Milling problems reduced output to about 500 fine ounces of gold and 250 ounces of silver per month.

Peru.—Banco Minero del Peru conducted an intensive program to encourage new gold placer mining in the area known as the "selva." In addition to deposits on the Inambari River, the bank promoted mining in the Chinchipe, Perené, Marcapata, Quince Mil, and San Juan de Oro areas. The "selva" was a source of about 4,000 ounces of placer gold in 1972 and was expected by the bank to supply over 20,000 ounces in 1973. Meanwhile, Natomas Company of Peru, subsidiary of Natomas Co. (United States), discontinued operations in

[26] U.S. Embassy, New Delhi, India. State Department Airgram A-191, May 31, 1973, pp. 54–56.

[27] Bevan, P. A. Rosita Mine—A Brief History and Geological Description. Can. Min. and Met. Bull., v. 66, No. 8, August 1973, pp. 81–84.

early 1972 at its gold placer properties about 30 miles north of Lake Titicaca. The bulk of Peruvian gold in 1973 continued to come from six mines of the Cerro de Pasco Corp., the Cobriza, Cerro de Pasco, Yauricocha, San Cristobal, Casapalca, and Morococha. Metals were refined at the La Oroya metallurgical complex.

Philippines.—Gold production was lower in 1973, mainly because of declining byproduct output from copper mining. The Philippine Monetary Board pursued plans for the Central Bank to establish a gold refinery which would treat the country's gold ore products.

Rhodesia, Southern.—The Rhodesian Government introduced an assistance program of "establishment loans" carrying a 6% rate of interest under which the gold miner was not required to repay the loan if the project failed or if the free market gold price fell below U.S. $55 per ounce. By the end of 1972, three loans were granted, two were under final approval, and eight applications were under study. In 1973, four new gold mines were being brought into production and two others were under development. Among gold mines reopened were the Champion, near Odzi, and the Bar-Twenty at Gwanda. As a result of higher gold prices, Falcon Mines Ltd., one of Rhodesia's largest gold-mining groups, increased its ore reserve estimate to 781,000 short tons averaging 0.33 ounce of gold per ton. The group planned renewed operations at its Turkois and Venice mines after dewatering.

South Africa, Republic of.—For the third consecutive year, production dropped, falling 6% to 27.5 million ounces. Comparative data for gold producers reporting to the Chamber of Mines of South Africa (virtually all producers) showed a 4% increase in the tonnage of ore milled to 80.8 million short tons but a 10% decline in the average grade to 0.34 ounce per short ton in 1973. During the year, the grade for all mines including uranium producers dropped from an average 0.342 in the first quarter to 0.318 in the fourth quarter. The drop reflected producers' efforts to prolong effective life of the operations by exploiting lower grade sections of ore bodies.

Working revenue of gold mines rose by more than 53% to R1,754 million ($2,613 million) over the 1972 figure; however, working costs also rose by nearly 25% to R770.3 million ($1,148 million), owing to increased labor and equipment expenses. Moreover, because of greater working depths labor productivity was estimated to have dropped by 10% since 1969, a reference year. Improved productivity and technology were to receive priority attention during 1974 according to the Mine Managers Association meeting in Johannesburg. Capital expenditure on gold mining was reported 115% higher in 1973, increasing by during 1973. Working profits of gold mines associated with the Chamber of Mines rose 88% during 1973 to R983.3 million ($1,466 million). Tax revenues paid from these profits to the South African Government were reported 115% higher in 1973, increasing by R267 million ($398 million). During the year the South African Central Bank increased its gold reserves 6% or 1.08 million ounces to nearly 19 million ounces, in effect withholding about 4% of production from world markets.

As in past years, the bulk of gold production came from the Transvaal region of the country, and 25% to 30% was produced in the Orange Free State. The West Driefontein mine, about 20 miles west of Johannesburg, remained the world's largest and richest gold producer with an output of 2.35 million ounces from ores averaging 0.904 ounce per ton. Other mines producing over 1 million ounces in 1973 included Vaal Reefs, Western Deep Levels, Western Holdings, President Brand, Free State Geduld, Harmony, Hartebeestfontein, Buffelsfontein, Blyvooruitzicht, and President Steyn. The lowest average grade mined by any of 40 principal gold producers was 0.096 ounce per ton at the East Daggafontein mine; the highest average grade was at the West Driefontein.

A tributing agreement between the West and East Driefontein mines, whereby ores were transported through West Driefontein workings, was ended in March, and stoping began in the No. 4 shaft area of the East Driefontein for the first time since 1968 when workings were flooded. A new mill at the East Driefontein mine was scheduled for completion early in 1975 and was to be the largest gold mill in the Republic of South Africa. Operations were to expand from 960,000 tons in 1973 to 2.17 million tons in 1976. At the Western Deep Levels mine, world's deepest, operations were conducted about 12,000 feet below the surface and plans were considered to go to 14,000 feet. The President Steyn No. 4 shaft, 7,750 feet deep and the world's deepest single-lift shaft, was completed, providing new capacity for an additional 246,000 tons of ore per month. On the Buffelsdorn farm, southwest of Western Deep Levels, a drill hole 8,500 feet deep cut the Ventersdorp contact reef, and a 2.3-foot section sampled contained 4.2 ounces of gold and 1.1 pound of uranium per ton of ore. The Vaal Reefs mine operators planned a large capital spending program, with about $37 million budgeted for the 1974 fiscal year. Ore production at Vaal Reefs and at Western Deep Levels was scheduled to rise to 6.1 and 3.2 million tons per year, respectively, by the end of 1974. Gold Fields of South Africa Ltd. planned a large new mine in the Deelkraal area to begin production about 1980. A $150 million capital investment was considered. The Brakpan mine was scheduled to reopen by the end of 1974 with output of 240,000 tons of ore per year and a minimum cutoff grade of 0.14 ounce per ton.

In the Orange Free State, south of the President Brand and President Steyn mines, the new Jurgens Hof mine, a $60 million investment, was under development. The mine was scheduled for production in 1978 at 864,000 tons of ore per year, the ores to be treated at the St. Helena cyanide mill nearby. The Elsberg and Western Areas mines were scheduled to merge operations for efficiency. Several nearby depleted mines had their lives extended as a result of higher gold prices and remained in operation after reassessing of reserves. Total general ore reserves of South African gold mines rose 30% to 182 million tons at the end of 1973. Grades were estimated to be slightly lower for most mines, but stoping widths were slightly greater than in 1972.

U.S.S.R.—Soviet gold sales to other countries were estimated at about 6 million to 9 million ounces in 1973, compared with 5 million to 6 million ounces in 1972. The Government's gold reserves were believed to be about 65 million ounces. In Siberia near the Arctic Circle, new placer gold operations were underway in the Bilibino region, while production declined from the Kolyma region where deposits were approaching exhaustion. A new nuclear powerplant was expected to begin supplying electricity to the Bilibino operations. The bulk of Soviet gold production continued to come from areas east of the Lena River.

TECHNOLOGY

Federal Bureau of Mines scientists assisted mine operators in evaluating the effectiveness of cyanide leaching and activated carbon gold extraction processes on their ores. Investigations of heap-leaching, which entails sprinkling weak cyanide solutions over the top of an open mound or leveled heap of ore and collecting the enriched solutions for gold extraction, revealed that, in general, for amendable ores 67% to 95% of the gold present could be extracted in 4 to 42 days. Extraction rates were dependent on coarseness of both gold and ore. Successful commercial applications of the process have been demonstrated with mine-run stripping waste at the Cortez mine in Nevada and on selected stripping material crushed to ¾-inch at the Carlin mine, also in Nevada.

At the Homestake mine in Lead, S. Dak., a carbon-in-pulp pilot plant, utilizing activated carbon as a gold collector mixed with the cyanide solutions and subsequently screened out, showed that 90% to 95% of the gold in a 0.15-ounce-per-ton slime feed could be successfully extracted this way. In March 1973, a 2,350-ton-per-day plant utilizing the carbon-in-pulp process was placed in operation at Lead, permitting the closure of an outmoded plate-and-frame filter-type leaching plant. After correction of minor problems with aeration, the unit operated fully up to expectations.

Slow stripping of gold from the activated carbon at atmospheric pressure remained a problem, and trials continued at several locations of a Bureau of Mines invented high-temperature stripping process that would significantly reduce stripping time, labor, and reagent requirements. In connection with this, work was in progress to accumulate data on equilibrium loading and desorption isotherms for gold and silver activated-carbon systems.

A sample tested by the Bureau of Mines from the Buckhorn gold mine, which is under development by the Carlin Gold Mining Co., showed 94% recovery of gold after grinding to 35 mesh, using activated carbon in a carbon-in-pulp test. Further tests indicated that heap leaching of the ore sized between minus 2 inches and plus 35 mesh, followed by adsorption on activated carbon, would provide recoveries of 83% of the gold in the coarse fraction and 68% of the total gold in the original ore; 17% of the total gold remained in the minus 35-mesh material.

At the new Gold Acres property of Cortez Gold Mines in north-central Nevada, a Bureau of Mines-type expanded-bed activated-carbon unit consisting of five open columns side-by-side began processing heap-leach solutions from adjacent prepared dumps. A high-temperature stripping unit was operated to remove the gold from the carbon; gold removal from the solution was virtually 100% before recycling to the dumps.

Laboratory investigations were reported using thiourea in an acid system at a pH of 1.0 to extract gold and silver with a view toward application to in situ leaching.[28] The effectiveness of the thiourea was said to be about 75% in comparison with cyanide, but the compound was believed to be more acceptable for in situ leaching for environmental reasons. The precious metals were recovered from solutions by conventional zinc dust precipitation or charcoal adsorption methods. Research was successful on a method of gold recovery from arsenopyrite and carbonaceous and oxidized gold ores employing sulfuric acid in the presence of sodium chloride to form a gold chloride complex.[29] In another process, gold was recovered from ore leaching solutions containing 4% to 80% concentrated hydrochloric acid using tetrahydrofuran to form a gold complex and extracting the complex with either methylene chloride or methylene bromide.[30] Gold was also extracted from gold leach solutions by treating an acidified solution with a chloride ion to form a gold complex, next passing the solution through a resin adsorption bed, and then stripping the resin with acetone, followed by evaporation and electrolysis.[31] A ketonic solvent containing iodine was used in another process to recover gold from ores or gold alloys,[32] and hydrogen sulfide in an oxidizing leach solution followed by aqua regia treatment was used to extract gold and platinum-group metals from copper-bearing mattes and sulfide ores in still another process.[33]

A group of articles was published on the treatment and destruction of cyanide solutions after use.[34] Most Canadian gold mills on which sample data were obtained were found to release cyanide in effluents exceeding 0.1 ppm, the proposed maximum of the Ontario Ministry of the Environment. Of four methods commonly used to dispose of cyanide wastes—oxidation, dilution with water or with other wastes, acidification and dilution or resulting gas with air, and alkaline chlorination—most Canadian operators applied only the first two. In a Film Layer Purification Chamber (FLPC) process, ozone, produced by electric discharge, was contacted with cyanide wastes sprayed into a chamber. Using this process, 91% to 97% of the cyanide present was decomposed in less than 2 minutes contact time. A commercial prototype plant was under construction. The metal-finishing industry produces a wide range of concentrations and volumes of cyanide wastes in periodic discharges. Generally, electrolytic destruction is used for high cyanide concentrations followed by oxidation, but a new system introduces a copper catalyst into the waste stream, the mixture then passing through an oxygen-bearing gas and finally through a carbon tower.

Cyanidation of gold ores following flotation was described at the Giant Yellowknife mine in Canada's Northwest Territories.[35]

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[28] Northern Miner (Toronto). In Situ Leaching of Gold With New Solvent System. V. 58, No. 50, Mar. 1, 1973, p. 12.

[29] Scheiner, B. J., and R. E. Lindstrom (assigned to the Secretary of the Interior). Recovery of Gold From Ores. U.S. Pat. 3,764,650, Oct. 9, 1973.

[30] Ziegler, M. (assigned to W. C. Heraeus GmbH). Process for the Quantitative Recovery of Gold From Aqueous Solutions. U.S. Pat. 3,734,722, May 22, 1973.

[31] Fritz, J. S., and W. G. Millen (assigned to U.S. Atomic Energy Commission). Gold Recovery From Aqueous Solutions. U.S. Pat. 3,736,126, May 29, 1973.

[32] Wilson, H. W. (assigned to Golden Cycle Corp.). Process for Separation and Recovery of Gold. U.S. Pat. 3,778,252, Dec. 11, 1973.

[33] Hougen, L. R., and H. Zachariasen (assigned to Falconbridge Nickel Mines Ltd.). Process for Recovery of Precious Metals From Copper-Containing Material. U.S. Pat. 3,767,760, Oct. 23, 1973.

[34] Coulter, K. R. Cyanide Treatment in the Metal Finishing Industry. Can. Min. J., v. 94, No. 6, June 1973, pp. 33–34.

Edmonds, C. J. Cyanide Destruction (Gold Mill Effluents). Can. Min. J., v. 94, No. 6, June 1973, pp. 34, 36.

Joe, E. G. Cyanide Elimination From Mill Effluents. Can. Min. J., v. 94, No. 6, June 1973, p. 30.

Mathieu, G. I. The FLPC Process for Cyanide Destruction. Can. Min. J., v. 94, No. 6, June 1973, pp. 30, 32.

Pawson, H. E., Review of Cyanide Elimination Methods. Can. Min. J., v. 94, No. 6, June 1973, pp. 30, 32.

[35] Pawson, H. E. Giant's Milling Operation. Can. Min. J., v. 94, No. 6, June 1973, pp. 21–22.

Arsenic and antimony were removed by roasting before final cyanidation; Cottrell dusts containing these metals were treated by a cyanide leach-charcoal recovery process for lost gold. Effects of various alkalis and impurities on cyanide dissolution of gold were investigated.[36] Best extraction was achieved with sodium carbonate (soda ash). Lime, which is universally used, was found to have deleterious effects, especially with refractory ore, although its use tended to keep the consumption of cyanide low.

Three reports were completed covering work by the Bureau of Mines under the Heavy Metals Program (1966–70).[37] Work showed that underground mining of the Six-Mile placer gold deposit at Badger Hill, Nevada County, Calif. (selected as an example) would be uneconomical at then-existing prices but that potential existed if marketable gravel products could be produced at the same time. It was concluded that, generally, for the Tertiary channel gravel deposits of northern California, mining could only be conducted with marginal profits unless the price of gold remained substantially above $70 per ounce or there was significant recovery of byproduct materials. Studies at the Badger Hill placer mine indicated that the bulk of the gold is within 40 feet of bedrock and occurs in stacked, lenticular zones of cemented gravel largely confined to the relatively narrow, meandering course of the deepest portion of the bedrock channel. Techniques were suggested for improved drilling, sampling, and delineation of the pay zones.

Research on new gold-mining methods has resulted in development of a swing hammer rock-cutting machine that is particularly adapted to thin continuous veins or reefs such as those in South African gold mines.[38] Nine experimental machines were built and tested at the Doornfontein and Stilfontein gold mines, Republic of South Africa, mining out up to 1,300 square feet of vein area in 1 month, using one machine on a single-shift basis. Stoping widths were maintained by taking alternate top and bottom cuts, leaving the middle ore section, about 1.3 feet thick, to break out by itself. In a related development, a patent was issued on a method by which slots or holes were cut alongside a reef or vein by combined percussive and oscillatory action and the ore extracted by bursting due to natural rock pressures.[39] With a possible view to the future, a patent was issued on a method using a laser beam to fracture a rock face to a depth of several inches.[40] The technique was said to be particularly adapted to mining narrow seams of gold ore. Undersea mining of deposits containing gold and platinum was the subject of another patent.[41]

The Federal Bureau of Mines prepared a report discussing the potential for renewed lode gold mining in central Alaska near Fairbanks.[42] Inferred remaining resources in the area described were estimated at 4 million ounces. Details were given on gold placer deposits in Alaska,[43] Utah,[44] and Nevada[45] in a continuation of a U.S. Geological Survey series started in 1972. The Geological Survey reported on a gold anomaly found by soil sampling near the Yellow Pine tungsten mine in Valley County, Idaho.[46] The mean value of 23 samples

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[36] Donyina, D. K. A. Factors Affecting Dissolution of Gold From Refractory Flotation Tailings. Can. Min. J., v. 94, No. 6, June 1973, pp. 20, 58.

[37] Johnson, T. B., W. R. Sharp, and J. N. Williams. Mine Systems Analysis—Tertiary Channel Deposits. The Badger Hill Pit, San Juan Ridge, Nevada County, Calif. BuMines Open-File Rept. 4–74, 1973, 77 pp.; available for consultation at the Bureau of Mines libraries in Pittsburgh, Pa., Twin Cities, Minn., Denver, Colo., and Spokane, Wash., and at the Central Library, U.S. Department of the Interior, Washington, D.C., and from the National Technical Information Service (NTIS), Springfield, Va., PB 226 723.

McLellan, R. R. Summary of Heavy Metals Studies at San Juan Ridge, Nevada County, Calif. BuMines Open-File Rept. 5–74, 1973, 87 pp.; available at locations shown above and from NTIS, PB 226 694.

McLellan, R. R., R. D. Berkenkotter, R. C. Wilmot, and R. L. Stahl. Drilling and Sampling Tertiary Gold-Bearing Gravels at Badger Hill Nevada County, Calif. BuMines Open File Rept. 6–74, 1973, 80 pp.; available at locations shown above but not from NTIS.

[38] Mining Magazine (London). Rock Cutting Machines For Production Trials in S. Africa. V. 129, No. 2, August 1973, pp. 125–127.

[39] Hilton, A. R. (assigned to Mining Developments, A.G.). Method and Apparatus for Mining Vein Material Only. U.S. Pat. 3,758,160, Sept. 11, 1973.

[40] Schumacher, B. W. (assigned to Westinghouse Electric Corp.) Corpuscular Beam in Mining and Excavation. U.S. Pat. 3,718,367, Feb. 27, 1973.

[41] Lindelof, L. A. (assigned to QVA Corp.). Apparatus and Process for Undersea Mining of Mineral Bearing Sand and Gravel. U.S. Pat. 3,731,975, May 8, 1973.

[42] Thomas, B. I. Gold-Lode Deposits, Fairbanks Mining District, Central Alaska. BuMines IC 8604, 1973, 16 pp.

[43] Cobb, E. H. Placer Deposits of Alaska. U.S. Geol. Survey Bull. 1374, 1973, 213 pp.

[44] Johnson, M. G. Placer Gold Deposits of Utah. U.S. Geol. Survey Bull. 1357, 1973, 26 pp.

[45] Johnson, M. G. Placer Gold Deposits of Nevada. U.S. Geol. Survey Bull. 1356, 1973, 118 pp.

[46] Leonard, B. F. Gold Anomaly in Soil of the West End Creek Area, Yellow Pine District, Valley County, Idaho. U.S. Geol. Survey Circ. 680, 1973, 16 pp.

was 0.085 ounce of gold per ton of soil material.

Conglomerates were found to contain possibly significant amounts of gold in another Geological Survey study, which established the approximate ranges of values in the Harebell and Pinyon Formations in Northwestern Wyoming.[47] Preliminary analyses showed an average of 65 and maximum of 1,000 parts per billion (ppb) of gold in the Harebell Formation and an average of 84 and maximum of 8,700 ppb of gold in the Pinyon Formation. It was estimated that a volume of 75 cubic miles of these conglomerates was present in the Jackson Hole region.

In mineralogical studies it was found that gold and arsenic in unoxidized ores of the Carlin and Cortez gold mines in Nevada were the most abundant in pyrite.[48] No association was found between gold and carbonaceous material, which was a particularly interesting revelation because a carbon and gold relationship in these two mines has been widely publicized in the past. Geochemical studies were said to suggest the presence in British Columbia of Carlin and Cortez type gold deposits.[49] Douglas fir needles were included in the evidence. In another study, it was concluded that geochemical abundance data do not provide reliable guides to areas favorable for gold mineralization and, furthermore, such data do not help identify source rocks or clarify natural processes concentrating gold.[50]

The content of gold and molybdenum in a large number of copper deposits was investigated, and it was found that nearly every deposit that contained significant molybdenum produced only relatively small amounts of gold.[51] Age and relationships of mineralization in gold deposits were subjects of other articles.[52]

Mine fires occur periodically in South African gold mines where extensive amounts of timber are used in stoping and for pack supports. Because of increasing concern, the system of rescue and firefighting was examined, and procedures and strategies were reported.[53] Causes of variations in different gold placer sampling techniques were discussed in an article, which favored bulk sampling to reduce error.[54] Increased interest in reclaiming gold from old tailings prompted a report on experiences at the Cornucopia mine in northeastern Oregon.[55]

The subject of byproduct gold production including unit processing costs was studied by the Bureau of Mines.[56] Direct unit costs for byproduct production operations at 1,420 ounces per week were estimated at 25.4 cents per ounce of gold produced; unit depreciation costs for a similar size plant over 10 years were estimated at 2.4 cents per ounce of product. Byproduct gold supply was shown to be relatively unresponsive to gold prices.

Smelting and refining of gold was described at the Rand refinery in the Republic of South Africa.[57] The plant, which is

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[47] Love, J. D. Harebell Formation (Upper Cretaceous) and Pinyon Conglomerate (Uppermost Creataceous and Paleocene), Northwestern Wyoming. U.S. Geol. Survey Prof. Paper 734-A, 1973, 54 pp.

[48] Wells, J. D., and T. E. Mullens. Gold-Bearing Arsenian Pyrite Determined By Microprobe Analysis, Cortez and Carlin Gold Mines, Nevada. Econ. Geol., v. 68, No. 2, March–April 1973, pp. 187–201.

[49] Warren, H. V., and J. H. Hajek. An Attempt To Discover a "Carlin-Cortez." Western Miner, v. 46, No. 10, October 1973, pp. 124–134.

[50] Tilling, R. I., D. Gottfried, and J. J. Rowe. Gold Abundance in Igneous Rocks: Bearing On Gold Mineralization. Econ. Geol., v. 68, No. 2, March–April 1973, pp. 168–184.

[51] Kesler, S. E. Copper, Molybdenum, and Gold Abundances in Porphyry Copper Deposits. Econ. Geol., v. 68, No. 1, January–February 1973, pp. 106–112.

[52] Czamanske, G. K., G. A. Desborough, and F. E. Goff. Annealing History Limits For Inhomogeneous, Native Gold Grains As Determined From Au-Ag Diffusion Rates. Econ. Geol., v. 68, No. 8, December 1973, pp. 1275–1288.

Fleischer, R., and P. Routhier. The "Consanguineous" Origin of a Tourmaline-Bearing Gold Deposit: Passagem de Mariana (Brazil). Econ. Geol., v. 68, No. 1, January–February 1973, pp. 11–12.

Nash, J. T., and C. G. Cunningham, Jr. Fluid-Inclusion Studies of the Fluorspar and Gold Deposits, Jamestown District, Colorado. Econ. Geol., v. 68, No. 8, December 1973, pp. 1247–1262.

Page, R. W., and I. McDougall. Ages of Mineralization of Gold and Porphyry Copper Deposits in the New Guinea Highlands. Econ. Geol., v. 67, No. 8, December 1972, pp. 1034–1048.

[53] Jamieson, D. M. Underground Fires. Min. Mag. (London) v. 128, No. 6, June 1973, pp. 430–439.

[54] Berry, J. Comprehension of Sampling Methods Vital In Gold Placer Exploration. Northern Miner (Toronto), v. 58, No. 51, Mar. 8, 1973, p. 59.

[55] Bean, J. J. Tale of Tails: Learn To Expect the Unexpected When Remining Old Tailings Ponds. World Mining, v. 9, No. 3, May 1973, p. 52.

[56] Petrick, A., Jr., H. J. Bennett, K. E. Starch, and R. C. Weisner. The Economics of Byproduct Metals (In Two Parts): 1. Copper System. BuMines IC 8569, 1973, 15 pp.

[57] Engineering and Mining Journal. Rand Gold Refinery—Biggest Little Plant in the World. V. 173, No. 11, November 1972, pp. 172–174.

located about 10 miles west of Johannesburg, processed all of the country's gold production and had capacity estimated at 40 million troy ounces of gold per year.

The quarterly series of the Chamber of Mines of South Africa contained a variety of new articles on gold uses and technology.[58] Metallurgical studies were completed on interdiffusion of cobalt and gold,[59] contamination on electroplated gold surfaces,[60] diffusion of gold in silicon,[61] and temperature effects on stability of gold-tin alloys.[62]

[58] Chamber of Mines of South Africa. Research Organization (Johannesburg). Gold Bull., v. 6, Nos. 1–4, 1973 issues (quarterly publication).

[59] Braun, J. D., and G. W. Powell. Reaction Diffusion and Associated Nonequilibrium Effects in the Au-Co System. Met. Trans., v. 4, No. 5, May 1973, pp. 1207–1212.

[60] Malm, D. L., and M. J. Vasile. A Study of Contamination on Electroplated Gold, Copper, Platinum, and Palladium. J. Electrochem. Soc., v. 120, No. 11, November 1973, pp. 1484–1487.

[61] Huntley, F. A., and A.F.W. Willoughby. The Effect of Dislocation Density on the Diffusion of Gold in Thin Silicon Slices. J. Electrochem. Soc., v. 120, No. 3, March 1973, pp. 414–422.

[62] Jena, A. K., B. C. Giessen, and M. B. Bever. On the Metastability of an Au-Sn Phase Prepared By Splat Cooling. Met. Trans., v. 4, No. 1, January 1973, pp. 279–287.

Table 3.—Mine production of recoverable gold in the United States, by State

(Troy ounces)

State	1969	1970	1971	1972	1973
Alaska	21,227	34,776	13,012	8,639	7,107
Arizona	110,878	109,853	94,038	102,996	102,848
California	7,904	4,999	2,966	3,974	3,647
Colorado	25,777	37,114	42,031	61,100	63,422
Idaho	3,403	3,128	3,596	2,884	2,696
Montana	24,189	22,456	15,613	23,725	27,806
Nevada	456,294	480,144	374,878	419,748	260,437
New Mexico	8,952	8,719	10,681	14,897	13,864
Oregon	875	256	244	(1)	(1)
South Dakota	593,146	578,716	513,427	407,430	357,575
Tennessee	126	124	192	176	68
Utah	433,385	408,029	368,996	362,413	307,080
Washington [1]	47,020	55,008	55,434	41,961	29,200
Total	1,733,176	1,743,322	1,495,108	1,449,943	1,175,750

[1] Production of Pennsylvania, Washington, and Wyoming (1969), North Carolina (1971), and Oregon (1972 and 1973) combined to avoid disclosing individual company confidential data.

Table 4.—Mine production of recoverable gold in the United States, by month

(Troy ounces)

Month	1972	1973
January	117,605	102,252
February	131,733	104,482
March	139,489	102,045
April	131,660	99,336
May	146,182	101,693
June	131,544	102,665
July	106,054	93,537
August	89,035	97,374
September	107,000	87,114
October	123,382	102,554
November	114,031	91,403
December	111,778	91,295
Total	1,449,943	1,175,750

Table 5.—Twenty-five leading gold-producing mines in the United States in 1973, in order of output

Rank	Mine	County and State	Operator	Source of gold
1	Homestake	Lawrence, S. Dak	Homestake Mining Co	Gold ore.
2	Utah Copper	Salt Lake, Utah	Kennecott Copper Corp	Copper, gold ores.
3	Carlin	Eureka, Nev	Carlin Gold Mining Co	Gold ore.
4	Cortez	Lander, Nev	Cortez Gold Mines	Do.
5	Sunnyside	San Juan, Colo	Standard Metals Corp	Lead-zinc ore.
6	Ruth Pit	White Pine, Nev	Kennecott Copper Corp	Copper, gold ores.
7	Knob Hill	Ferry, Wash	Knob Hill Mines, Inc	Gold ore.
8	San Manuel	Pinal, Ariz	Magma Copper Co	Copper ore.
9	New Cornelia	Pima, Ariz	Phelps Dodge Corp	Copper, gold ores.
10	Copper Queen-Lavender Pit	Cochise, Ariz	do	Copper ore.
11	Berkeley Pit	Silver Bow, Mont	The Anaconda Company	Do.
12	Idarado	Ouray and San Miguel, Colo	Idarado Mining Co	Copper-lead-zinc ores.
13	Morenci	Greenlee, Ariz	Phelps Dodge Corp	Copper ore.
14	Leadville	Lake, Colo	American Smelting & Refining Co	Lead-zinc ore.
15	Magma	Pinal, Ariz	Magma Copper Co	Copper ore.
16	Copper Canyon	Lander, Nev	Duval Corp	Do.
17	Continental	Grant, N. Mex	UV Industries, Inc	Do.
18	Hogatza River	Yukon River Region, Alaska	do	Placer.
19	Christmas	Gila, Ariz	Inspiration Consolidated Copper Co	Copper ore.
20	Tyrone	Grant, N. Mex	Phelps Dodge Corp	Do.
21	Trixie	Utah, Utah	Kennecott Copper Corp	Gold-silver ore.
22	Bonney-Misers Chest	Hidalgo, N. Mex	Federal Resources Corp	Copper ore.
23	Pima	Pima, Ariz	Pima Mining Co	Do.
24	Butte Hill Copper Mines	Silver Bow, Mont	The Anaconda Company	Do.
25	Copper Cities	Gila, Ariz	Cities Service Co	Do.

Table 6.—Production of gold in the United States in 1973, by State, type of mine, and class of ore yielding gold, in terms of recoverable metal

State	Placer (troy ounces of gold)	Lode: Gold ore		Lode: Gold-silver ore		Lode: Silver ore	
		Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold
Alaska	7,107	--	--	--	--	--	--
Arizona	6	(1)	(1)	[2] 100,490	[2] 460	--	--
California	3,110	[2] 3,412	[2] 403	(3)	(3)	--	--
Colorado	1,661	[2] 115,208	[2] 1,407	(3)	(3)	(3)	(3)
Idaho	--	--	--	226	41	312,620	673
Montana	22	948	180	16,974	1,913	23,053	175
Nevada	130	(4)	(4)	(4)	(4)	2,711	271
New Mexico	--	(4)	(4)	--	--	--	--
South Dakota	--	1,573,763	357,575	--	--	--	--
Utah	--	(5)	(5)	(5)	(5)	--	--
Other States [6]	38	61,736	29,080	648	82	--	--
Total	12,074	1,755,067	388,645	118,338	2,496	338,384	1,119
Percent of total gold	1	--	33	--	(7)	--	(7)

State	Lode: Copper ore		Lode: Lead ore		Lode: Zinc ore	
	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold
Alaska	--	--	--	--	--	--
Arizona	149,119,196	101,923	--	--	--	--
California	--	--	(5)	(5)	[2] 226,152	[2] 487
Colorado	(8)	(8)	(8)	(8)	(5)	(5)
Idaho	(5)	(5)	(5)	(5)	--	--
Montana	18,976,738	22,981	180	18	--	--
Nevada	[2] 12,482,339	[2] 260,031	--	--	(5)	(5)
New Mexico	[2] 26,416,479	[2] 13,656	--	--	--	--
South Dakota	--	--	--	--	--	--
Utah	(5)	(5)	--	--	--	--
Other States [6]	--	--	--	--	--	--
Total	206,994,752	398,591	180	18	226,152	487
Percent of total gold	--	34	--	(7)	--	(7)

State	Lode: Copper-lead, lead-zinc, copper-zinc, and copper-lead-zinc ores		Lode: Oil tailings, etc.		Lode: Total	
	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold [9]	Short tons	Troy ounces of gold
Alaska	--	--	--	--	--	7,107
Arizona	93,284	453	670	6	149,313,640	102,848
California	[2] 3,422	[2] 17	3	117	6,837	3,647
Colorado	862,257	59,526	7,068	341	1,210,685	63,422
Idaho	[2] 1,090,336	[2] 1,982	--	--	1,403,182	2,696
Montana	235	41	66,693	2,476	19,084,821	27,806
Nevada	--	--	32	5	12,485,082	260,437
New Mexico	[2] 129,909	[2] 208	--	--	26,546,388	13,864
South Dakota	--	--	--	--	1,573,763	357,575
Utah	[2] 38,597,757	[2] 307,078	--	--	38,597,757	307,080
Other States [6]	1,322,930	68	--	--	1,385,314	29,268
Total	42,100,130	369,373	74,466	2,947	251,607,469	1,175,750
Percent of total gold	--	32	--	(7)	--	100

1 Included with gold-silver ore.
2 Includes other ore classes to avoid disclosing company confidential information. See additional footnote entries in table.
3 Included with gold ore.
4 Included with copper ore.
5 Included with copper-lead, lead-zinc, copper-zinc, and copper-lead-zinc ores.
6 Includes Oregon, Tennessee, and Washington.
7 Less than ½ unit.
8 Included with zinc ore.
9 Includes byproduct gold recovered from tungsten ore in California, fluorspar ore in Colorado, and uranium ore in Utah.

Table 7.—Gold produced in the United States from ore, old tailings, etc., in 1973, by State and method of recovery, in terms of recoverable metal

State	Total ore, old tailings, etc., treated [1,2] (thousand short tons)	Ore and old tailings to mills					Crude ore, old tailings, etc., to smelters [1]	
		Thousand short tons [1,2]	Recoverable in bullion		Concentrates smelted and recoverable metal			
			Amalgamation (troy ounces)	Cyanidation (troy ounces)	Concentrates (short tons)	Troy ounces	Thousand short tons	Troy ounces
Arizona	181,426	181,033	--	--	3,405,828	100,801	393	2,041
California	7	5	--	--	1,572	427	2	110
Colorado	[3] 1,297	[3] 1,290	15,381	--	171,430	46,016	7	364
Idaho	1,658	1,656	--	--	184,858	2,614	2	82
Montana	19,085	18,976	--	--	405,219	22,860	109	4,924
Nevada	[3,4] 24,584	[3,4] 24,502	--	220,294	372,163	39,354	82	659
New Mexico	26,546	26,489	--	--	882,538	13,453	57	411
South Dakota	1,574	1,574	--	357,575	--	--	--	--
Utah	39,153	38,993	--	--	868,754	303,842	160	3,238
Other States [5]	[4] 3,733	[4] 3,732	--	5,442	185,124	23,587	1	201
Total	299,063	298,250	15,381	583,311	6,477,486	552,954	813	12,030

[1] Includes some non-gold-bearing ores not separable.
[2] Excludes tonnages of fluorspar, tungsten, and uranium ores from which gold was recovered as a byproduct.
[3] Includes tonnages from which gold is heap leached.
[4] Includes tonnages from which gold is vat leached.
[5] Includes Oregon, Tennessee, and Washington.

Table 8.—Gold produced at amalgamation and cyanidation mills in the United States and percentage of gold recoverable from all sources

Year	Bullion and precipitates recoverable (troy ounces)		Gold recoverable from all sources (percent)			
	Amalgamation	Cyanidation	Amalgamation	Cyanidation	Smelting [1]	Placers
1969	397,869	580,694	23.0	33.5	42.0	1.5
1970	353,957	638,966	20.3	36.7	40.8	2.2
1971	3,071	832,463	.2	55.7	43.0	1.1
1972	3,999	792,364	.3	54.6	44.2	.9
1973	15,381	583,311	1.3	49.6	48.1	1.0

[1] Crude ores and concentrates.

Table 9.—Gold production at placer mines in the United States, by method of recovery

Method and year	Mines producing	Washing plants	Material washed (thousand cubic yards)	Gold recoverable: Thousand troy ounces	Gold recoverable: Value (thousands)	Gold recoverable: Average value per cubic yard
Bucketline dredging:						
1971	2	3	740	7	$301	$0.407
1972	2	2	558	4	r 246	r.441
1973	2	2	649	4	402	.619
Dragline dredging:						
1971	--	--	--	--	--	--
1972	1	1	([1])	[2] 1	27	([3])
1973	3	3	[1] 55	[2] 1	115	[3] 2.091
Hydraulicking:						
1971	5	5	32	1	30	.938
1972	16	16	230	3	r 187	r.813
1973	12	12	245	2	167	.682
Nonfloating washing plants:						
1971	21	38	[1] 289	[2] 8	334	[3] 1.156
1972	35	35	[1] 123	[2] 5	r 291	r [3] 2.366
1973	34	34	[1] 32	[2] 5	454	[3] 14.188
Underground placer, small-scale mechanical and hand methods, and suction dredge:						
1971	12	2	6	([4])	10	1.667
1972	14	4	2	([4])	6	3.000
1973	20	3	19	([4])	43	2.263
Total placers:						
1971	40	48	[1] 1,067	[2] 16	675	r [3].829
1972	68	58	[1] 913	[2] 13	r 757	r [3].829
1973	71	54	[1] 1,000	[2] 12	1,181	[3] 1.181

r Revised.
[1] Excludes tonnage of material treated at commercial sand and gravel operations recovering byproduct gold.
[2] Includes gold recovered at commercial sand and gravel operations recovering byproduct gold.
[3] Gold recovered as a byproduct at sand and gravel operations not used in calculating average value per cubic yard.
[4] Less than ½ unit.

Table 10.—U.S. gold consumption in industry and the arts [e]

(Thousand troy ounces)

Industry group	1969	1970	1971	1972	1973
Jewelry and arts	3,839	3,340	4,299	4,344	3,473
Dental	710	658	750	750	679
Industrial, including space and defense	2,560	1,975	1,884	2,191	2,577
Total	7,109	5,973	6,933	7,285	6,729

[e] Estimated by Office of Domestic Gold and Silver Operations, U.S. Treasury Department.

Table 11.—U.S. exports of gold in 1973, by country

Destination	Ore, base bullion, and scrap: Quantity (troy ounces)	Ore, base bullion, and scrap: Value (thousands)	Refined bullion: Quantity (troy ounces)	Refined bullion: Value (thousands)
Belgium-Luxembourg	148,105	$12,912	--	--
Brazil	--	--	322	$21
Canada	2,946	257	169,069	13,517
Germany, West	24,964	1,982	--	--
Japan	643	78	--	--
Mexico	3,174	263	1,021	109
Sweden	314	38	--	--
Switzerland	1,195	105	2,055,207	82,328
United Kingdom	152,914	14,057	50,033	5,889
Uruguay	--	--	372,667	14,161
Venezuela	--	--	2,643	248
Total	334,255	29,692	2,650,962	116,273

Table 12.—U.S. imports (general) of gold in 1973, by country

Country	Ore and base bullion		Refined bullion	
	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)
Australia	35,217	$3,154	594	$70
Austria	--	--	32	2
Belgium-Luxembourg	8	1	--	--
Canada	23,206	2,142	1,475,112	135,332
Chile	3,090	266	--	--
Colombia	567	54	--	--
Dominican Republic	5	(1)	--	--
Fiji Islands	--	--	298	21
France	--	--	9,644	1,131
Germany, West	--	--	103	11
Guatemala	14	2	--	--
Honduras	3,164	162	--	--
Hong Kong	34	4	--	--
Iran	3	(1)	--	--
Italy	615	40	--	--
Japan	88	6	9,283	808
Korea, Republic of	1,228	97	--	--
Malaysia	391	8	--	--
Mexico	7,657	484	--	--
Netherlands	23	3	--	--
Nicaragua	16,013	1,224	--	--
Norway	5,002	179	--	--
Panama	55	6	688	65
Peru	27,657	2,014	--	--
Philippines	86,627	8,585	--	--
Portugal	562	37	--	--
Saudi Arabia	--	--	1,875	169
Singapore	14,456	659	--	--
South Africa, Republic of	415	23	12,904	1,116
Switzerland	12	(1)	1,224,393	114,694
U.S.S.R	63	6	793,609	74,711
United Kingdom	20	2	6,453	660
Venezuela	8,500	230	--	--
Yugoslavia	--	--	75,085	7,972
Total	234,692	19,388	3,610,073	336,762

1 Less than ½ unit.

Table 13.—Value of gold imported into and exported from the United States

(Thousand dollars)

Year	Exports	Imports
1971	51,249	283,947
1972	63,053	357,689
1973	145,965	356,150

Table 14.—Gold: World production [1] by country
(Troy ounces)

Country [2]	1971	1972	1973 p
North America:			
Canada	2,243,000	2,079,000	1,930,000
Costa Rica	r e 5,000	r e 5,000	7,806
El Salvador	3,503	2,861	5,232
Haiti e	3,000	3,000	3,000
Honduras	r 2,701	2,021	795
Mexico	150,915	146,061	132,557
Nicaragua	121,134	e 120,000	85,051
United States	1,495,108	1,449,943	1,175,750
South America:			
Bolivia	21,541	19,640	35,341
Brazil [3]	157,378	165,531	157,216
Chile	64,417	75,946	94,571
Colombia	188,847	186,816	216,243
Ecuador	11,028	e 11,000	e 11,000
French Guiana	2,315	997	e 1,000
Guyana	r 1,409	4,026	e 4,000
Peru	65,000	82,885	55,637
Surinam	643	e 600	e 600
Venezuela	18,567	19,776	19,201
Europe:			
Finland	17,489	17,619	e 17,700
France	65,620	58,126	e 60,000
Germany, West	1,704	e 1,700	e 1,700
Portugal	13,696	16,718	15,258
Romania e	60,000	60,000	60,000
Sweden	54,528	57,550	60,000
U.S.S.R. e	6,700,000	6,900,000	7,100,000
Yugoslavia	123,780	136,898	145,000
Africa:			
Angola	r 44	e 30	e 30
Cameroon	88	50	e 60
Congo (Brazzaville)	2,958	2,083	2,500
Ethiopia	24,499	20,784	19,575
Gabon	13,728	13,182	11,224
Ghana	697,517	724,051	722,531
Guinea e	4,000	4,000	4,000
Kenya	--	34	150
Liberia [4]	2,546	1,324	--
Mali e	30	30	30
Malagasy Republic	412	190	71
Mozambique	19	e 20	--
Niger	119	--	--
Nigeria	40	12	21
Rhodesia, Southern	501,551	e 502,000	e 500,000
South Africa, Republic of	31,388,631	29,245,273	27,494,603
Sudan	--	95	49
Tanzania	167	213	56
Zaire	171,685	81,566	133,522
Zambia [5]	9,866	e 11,400	e 11,500
Asia:			
China, People's Republic of e	50,000	50,000	50,000
India	118,569	105,776	106,097
Indonesia	10,600	10,899	e 48,000
Japan [6]	255,255	243,027	188,000
Khmer Republic e	4,000	4,000	4,000
Korea, North e	160,000	160,000	160,000
Korea, Republic of	28,807	17,072	16,300
Malaysia:			
Malaya	4,491	3,853	e 2,800
Sarawak	1,180	e 1,047	1,000
Philippines	637,048	606,730	572,319
Taiwan	19,496	17,882	22,197
Oceania:			
Australia	672,106	754,562	944,716
British Solomon Islands Protectorate	444	e 400	e 400
Fiji	89,129	89,670	79,983
New Zealand	9,418	13,511	e 13,000
Papua-New Guinea	24,071	409,125	566,216
Total	r 46,494,837	44,717,605	43,069,608

e Estimate. p Preliminary. r Revised.
[1] Unless otherwise indicated, production is on the basis of mine output.
[2] Gold is also produced in Bulgaria, Czechoslovakia, Spain, and probably in small quantities in Argentina, Burma, East Germany, Hungary, Thailand, and several other countries. However, available data are insufficient to make reliable output estimates. Data are lacking on clandestine activities.
[3] Bullion only; excludes gold from placer operations for which no data are available.
[4] Purchased by the Bank of Monrovia.
[5] Contained in blister copper, refinery muds, and electrolytic copper.
[6] Refinery production for Japan was as follows: 1971—772,652 ounces; 1972—845,628 ounces; 1973—1,052,775 ounces.

Graphite

By David G. Willard [1]

Crystalline natural graphite remained in short supply throughout 1973, and the market had grown perceptibly tighter by yearend. Prices of imported flake had risen by more than 20% and stocks were being heavily drawn upon. A principal cause of the shortage was a major decline in production in the Malagasy Republic, the main source of crystalline large-flake graphite. Supplies of amorphous graphite, however, remained sufficient, and attempts appeared to have been made to substitute it for the scarce crystalline flake.

Imports of natural graphite were up 21%, but the entire gain was in the amorphous form. Imports of crystalline flake slumped to 53% of the 1972 level. A steady rise continued in exports of natural graphite, which were 9% greater than in the previous year.

Demand continued its strong growth for a third consecutive year, compounding the already difficult supply problem. Some uses, particularly for crucibles, showed declines which appeared to have resulted from the inadequacy of supplies rather than any decline of industrial demand.

The manufactured graphite industry enjoyed another booming year as production registered an 11% gain. Almost all segments of the industry showed improved results compared with 1972 production, and prospects for 1974 remained good.

[1] Economist, Division of Nonmetallic Minerals—Mineral Supply.

Table 1.—Salient natural graphite statistics

	1969	1970	1971	1972	1973
United States:					
Consumption [e 1] ____short tons__	58,000	50,000	60,000	70,000	79,000
Exports ____do____	10,264	5,783	5,733	7,289	7,953
Value ____thousands__	$782	$701	$680	$888	$992
Imports for consumption [2] __short tons__	58,459	66,449	57,756	64,135	77,376
Value ____thousands__	$2,419	$3,027	$2,727	$3,847	$4,455
World: Production ____short tons__	414,194	r 433,047	r 433,925	r 397,682	NA

e Estimated. r Revised. NA Not available.
[1] Estimated demand has been substituted for the consumption survey results previously published, since the latter are incomplete. A figure comparable to the previous series appears as the total of table 3.
[2] Includes some manufactured graphite.

Legislation and Government Programs.—As part of Administration efforts to reduce strategic stockpile inventories, more than half of the natural graphite in the stockpiles was declared surplus by the General Services Administration (GSA). Of the three types of stockpiled graphite, about half of the Malagasy and Sri Lanka types, and all graphite of other types were placed on the surplus list. However, Congressional authorization for their disposal had not been obtained, and no sales were made. All stockpiled graphite which had previously been authorized for disposal had been sold, although some shipments were still being made during the year.

Responsibility for determining requirements for strategic materials was transferred from the Office of Emergency Preparedness to GSA. Authorization for disposal, however, still required congressional action.

Table 2.—Government yearend stocks of natural graphite

(Short tons)

Types of graphite	National stockpile	Supplemental stockpile	Total all stockpiles
Malagasy crystalline flake:			
Objective	4,900	--	4,900
Uncommitted excess	14,167	--	14,167
Total	19,067	--	19,067
Malagasy crystalline fines:			
Objective	1,835	1,465	3,300
Uncommitted excess	3,395	[1] 445	3,840
Total	5,230	[1] 1,910	7,140
Sri Lanka amorphous lump:			
Objective	2,792	308	3,100
Uncommitted excess	[2] 1,503	893	2,399
Total	[2] 4,295	1,204	5,499
Other than Malagasy and Sri Lanka, crystalline: Uncommitted excess	[3] 2,802	--	2,802

[1] Includes 1 short ton nonstockpile-grade material.
[2] Includes 56 short tons nonstockpile-grade material.
[3] Includes 867 short tons nonstockpile-grade material.

Source: General Services Administration. Stockpile Report to the Congress, July-December 1973. Statistical Supplement. 1974, pp. 15–16. And other General Services Administration information.

PRODUCTION

In 1973 natural graphite production in the United States was again from a single location, the Southwestern Graphite Co. mine near Burnet, Tex. Shipments from the mine were slightly lower than in 1972, and continued to account for only a small portion of the domestic supply. Other graphite deposits in New York, Alabama, and Texas continued to draw the interest of investigators contemplating the development or redevelopment of additional mines, but no mine openings occurred or were in prospect at yearend.

Production of manufactured graphite continued its upward trend in 1973. Output of 306,212 tons was up 11% from the 275,311 tons produced in 1972. Total value of production increased 20% to $220.0 million from $183.6 million the previous year. The use of powder and scrap material declined from 29,479 tons and $4.1 million in 1972 to 25,722 tons and $3.7 million in 1973.

Metallurgical use of manufactured graphite again showed advances as the metal industries continued at high rates of production. Other uses, such as mechanical products made of graphite, also continued to advance. Graphite fiber has apparently strengthened its initial commercial acceptance in sporting goods such as golf clubs and tennis rackets. The first experimental applications have been made in the automotive field, particularly in the racing area, where the strength to weight ratio is important. These are the first non-defense applications of the graphite fiber materials.

Table 3.—Production of manufactured graphite in the United States in 1973, by use

(Short tons and thousand dollars)

Use	Quantity	Value
Synthetic Graphite Products		
Electrodes	216,043	147,240
Crucibles & vessels	5,971	11,650
Motor brushes & machine shapes	5,345	11,145
Unmachined shapes	7,890	--
Cloth & fibers	72	--
Other [1]	70,891	49,931
Total	306,212	219,966
Synthetic Graphite Powder & Scrap	25,722	3,742
Grand total	331,934	223,708

[1] Quantity includes anodes, high modulus fibers & other. Value includes anodes, unmachined shapes, cloth, fiber, high modules fibers & other.

Manufactured graphite was produced at 25 plants in 1973, and some additional production for in-house use was likely. Therefore, the following list is probably not complete:

Company	Plant location
Airco, Inc., Speer Div	Niagara Falls, N.Y.
Do	Punxsutawney, Pa.
Do	St. Marys, Pa.
Avco Corp., Avco Systems Div	Lowell, Mass.
The Carborundum Co., Graphite Products Div	Hickman, Ky.
Do	Sanborn, N.Y.
Celanese Corp., Celanese Research Lab	Summit, N.J.
Fiber Materials, Inc	Graniteville, Mass.
Great Lakes Carbon Corp	Rosamond, Calif.
Do	Niagara Falls, N.Y.
Do	Morganton, N.C.
Hercules, Inc	Bacchus, Utah
HITCO	Gardena, Calif.
Morganite Modmor, Inc	Costa Mesa, Calif.
Ohio Carbon Co	Cleveland, Ohio
Pfizer, Inc.; Minerals Pigments & Metals Div	Easton, Pa.
Poco Graphite, Inc	Decatur, Tex.
Polycarbon, Inc	No. Hollywood, Calif.
Stackpole Carbon Co	Lowell, Mass.
Do	St. Marys, Pa.
Super Temp Co	Santa Fe Springs, Calif.
Union Carbide Corp	Niagara Falls, N.Y.
Do	Yabucoa, P.R.
Do	Columbia, Tenn.
Wickes Engineered Materials	Saginaw, Mich.

An expansion of the graphite fiber production facility at Bacchus, Utah, was announced by Hercules, Inc. New equipment will enable a doubling of the plant's output.[2]

[2] Chemical Engineering. CPI News Briefs. V. 80, No. 29, Dec. 24, 1973, p. 78.

CONSUMPTION AND USES

Demand for natural graphite remained on a strong uptrend in 1973, and the growth pattern was similar to that of 1972. Consumption in steel mills and foundries exhibited continued strength and again accounted for most of the increase. Use of graphite in brake and clutch linings and powdered metals was also considerably higher than in 1972. Consumption in the manufacture of crucibles and associated products declined sharply, probably resulting from the difficulty in obtaining Malagasy flake which is particularly important to that industry.

Total consumption of natural graphite was considerably greater than that shown in table 4, which reports only the results of a survey of known graphite consumers. Total graphite consumption is estimated to have been in the neighborhood of 79,000 tons in 1973.

Table 4.—Consumption [1] of natural graphite in the United States in 1973, by use
(Short tons)

Use	Crystalline		Amorphous [2]		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
Batteries	436	$243,383	508	$368,204	944	$611,587
Brake linings	681	339,258	1,914	726,816	2,595	1,036,074
Carbon products [3]	629	W	421	W	1,050	645,751
Crucibles, retorts, stoppers, sleeves, and nozzles	2,692	586,351	175	67,861	2,867	654,212
Foundries	4,606	W	18,159	W	22,765	3,819,752
Lubricants [4]	1,364	788,678	2,331	652,820	3,695	1,441,498
Pencils	1,472	711,416	746	193,117	2,218	904,533
Powdered metals	365	W	720	W	1,085	526,766
Refractories	961	112,870	7,418	575,114	8,379	687,984
Rubber	174	110,291	224	51,398	398	161,689
Steelmaking	556	93,843	11,249	4,095,995	11,805	4,189,838
Other [5]	4,297	877,059	351	200,997	4,648	1,078,056
Total	18,233	7,247,266	44,216	8,540,474	62,449	15,787,740

W Withheld to avoid disclosing individual company confidential data; included in "Total."
[1] Consumption data incomplete. Excludes small consuming firms.
[2] Includes mixtures of natural and manufactured graphite.
[3] Includes bearings and carbon brushes. Previously titled "Other mechanical products."
[4] Includes ammunition, packings, and seed coating.
[5] Includes paints and polishes, antiknock and other compounds, drilling mud, electrical and electronic products, insulation, magnetic tape, small packages, and miscellaneous and proprietary uses.

PRICES

Impelled by the continuing world shortage, graphite prices rose sharply in 1973. Since most of the U.S. supply is imported, domestic prices responded to the higher cost of foreign supplies. Prices of all the principal types of crystalline flake graphite imported by the United States were significantly above their 1972 levels, with increases ranging from 20% to 35%. Malagasy crystalline flake, the most important type of flake graphite and the one with the greatest decline in production, rose an average of 35% in price during the year. Mexican graphite, however, the principal amorphous type imported, remained unchanged in price. As a consequence, imports of Mexican graphite were up 33% in quantity compared with those of 1972.

Price quotations represent a range of prices. Actual prices are often on a negotiated basis between the buyer and seller. Therefore, the quotations which follow provide only a general guide to graphite prices and their trends. Another source of information, for imported graphite, is the average value per ton of the different classes of imports, which can be computed from table 6, although it should be kept in mind that these represent mainly shipments of unprocessed graphite.

No published source of domestic price quotations has been found which reflects the increases that have taken place in the last couple of years. Price information can be obtained from the companies which produce and import natural graphite. Representative prices of several types of imported graphite, published in the Engineering and Mining Journal, are shown below. All prices are f.o.b. the foreign port or border station and have been converted from metric tons.

	Per short ton	
	1972	1973
Flake and crystalline graphite, bags:		
Germany, West	$163–$929	$204–$1,179
Malagasy Republic	122– 336	159– 476
Norway	91– 145	109– 181
Sri Lanka	152– 259	181– 318
Amorphous, nonflake cryptocrystalline graphite (80% to 85% carbon):		
Korea, Republic of (bags)	22	27
Mexico (bulk)	22	22

FOREIGN TRADE

A further rise in exports of natural graphite occurred in 1973, continuing the uptrend begun the year before. Exports gained 9% to 7,953 tons compared with 7,289 tons in 1972. The principal buyer again was Canada which took 3,793 tons. Other countries purchasing several hundred tons apiece were the United Kingdom, Mexico, and Japan; and graphite was exported to 28 additional countries.

Imports of natural graphite increased sharply, but the rise did not signal an end to the graphite supply problem. The entire increase occurred in amorphous graphite imports from Mexico, while imports of crystalline graphite fell by more than 3,000 tons due to a 53% decline in receipts from the Malagasy Republic. The figures would appear to indicate an attempt on the part of industry to substitute the more plentiful amorphous graphite in products normally requiring crystalline flake, with a consequent increase in the quantities needed. Small increases occurred in imports of crystalline and amorphous graphite from the People's Republic of China and lump graphite from Sri Lanka, but the amounts were insignificant beside the shortfall in Malagasy flake.

Tables 5 and 6 give statistics on U.S. exports and imports of natural graphite in 1973.

Table 5.—U.S. exports of natural graphite, by country

Destination	Amorphous, crystalline flake, lump, or chip, and natural, n.e.c.			
	1972		1973	
	Quantity (short tons)	Value	Quantity (short tons)	Value
Argentina	35	$4,737	17	$2,327
Australia	174	15,487	280	30,585
Belgium-Luxembourg	60	8,258	48	6,522
Brazil	85	10,905	140	17,679
Canada	3,523	411,872	3,793	454,391
Chile	30	4,038	10	1,481
Colombia	--	--	67	9,691
Denmark	11	951	--	--
France	169	21,809	253	32,245
Germany, West	454	58,474	104	14,170
India	--	--	206	26,210
Iran	7	871	64	8,197
Italy	286	26,933	29	4,855
Jamaica	20	1,905	21	2,720
Japan	539	68,610	449	59,044
Malaysia	--	--	81	10,301
Mexico	396	51,692	633	79,788
Netherlands	135	18,618	59	6,500
New Zealand	20	1,450	--	--
Norway	7	840	--	--
Panama	102	14,856	21	3,535
Peru	95	14,150	55	8,074
Philippines	4	511	124	14,552
Portgual	38	3,988	--	--
Singapore	79	6,688	216	28,060
South Africa, Repulic of	50	4,390	21	2,685
Sweden	6	704	61	8,659
Switzerland	10	1,636	11	1,422
Taiwan	10	746	--	--
United Kingdom	518	73,549	924	118,174
Venezuela	381	53,533	193	32,104
Other	45	6,089	73	8,333
Total	7,289	888,290	7,953	992,304

Table 6.—U.S. imports for consumption of natural and artificial graphite, by country
(Short tons and thousand dollars)

Year and country	Natural: Crystalline flake: Quantity	Natural: Crystalline flake: Value	Natural: Crystalline lump, chip or dust: Quantity	Natural: Crystalline lump, chip or dust: Value	Natural: Other natural crude and refined: Quantity	Natural: Other natural crude and refined: Value	Artificial[1]: Quantity	Artificial[1]: Value	Total: Quantity	Total: Value
1971	4,882	697	73	21	52,476	1,953	325	56	57,756	2,727
1972:										
Austria	--	--	--	--	16	3	--	--	16	3
Canada	--	--	--	--	7	2	111	7	118	9
China, People's Republic of	--	--	--	--	734	115	--	--	734	115
France	12	4	--	--	--	--	--	--	12	4
Germany, West	828	302	--	--	1,350	288	9	6	2,187	593
Hong Kong	--	--	--	--	5	1	--	--	5	1
Italy	--	--	2	2	--	--	232	26	234	28
Japan	--	--	--	--	--	--	3	7	3	7
Korea, Republic of	--	--	--	--	144	8	--	--	144	8
Malagasy Republic	5,855	784	--	--	446	86	--	--	6,301	870
Malaysia	316	40	--	--	--	--	--	--	316	40
Mexico	--	--	--	--	47,438	1,068	11	7	47,449	1,075
Norway	30	4	119	11	3,419	397	--	--	3,568	412
South Africa, Republic of	--	--	--	--	40	4	--	--	40	4
Sri Lanka	--	--	--	--	2,810	634	--	--	2,810	634
Switzerland	--	--	--	--	--	--	6	3	6	3
Taiwan	--	--	--	--	99	19	--	--	99	19
Thailand	--	--	--	--	60	15	--	--	60	15
U.S.S.R	--	--	--	--	31	3	--	--	31	3
United Kingdom	2	1	--	--	--	--	--	--	2	1
Total	7,043	1,135	121	13	56,599	2,643	372	56	64,135	3,847
1973:										
Australia	--	--	--	--	11	2	--	--	11	2
Austria	--	--	--	--	10	2	--	--	10	2
Canada	1	(2)	--	--	3	1	309	35	313	36
China, People's Republic of	185	43	--	--	1,417	286	--	--	1,602	329
France	--	--	--	--	3	2	--	--	3	2
Germany, West	662	334	--	--	1,883	500	24	21	2,569	855
Hong Kong	--	--	--	--	35	6	--	--	35	6
Italy	--	--	4	4	--	--	--	--	4	4
Japan	--	--	--	--	(2)	(2)	13	31	13	31
Korea, Republic of	--	--	--	--	466	17	--	--	466	17
Malagasy Republic	2,732	434	--	--	860	221	--	--	3,592	655
Mexico	44	8	--	--	63,136	1,418	(2)	(2)	63,180	1,426
Norway	89	11	--	--	2,241	290	--	--	2,330	301
Sri Lanka	--	--	165	45	2,822	681	--	--	2,987	726
Switzerland	--	--	--	--	--	--	36	22	36	22
Taiwan	--	--	--	--	60	14	--	--	60	14
U.S.S.R	--	--	--	--	165	27	--	--	165	27
Venezuela	--	--	--	--	(2)	(2)	--	--	(2)	(2)
Total	3,713	830	169	49	73,112	3,467	382	109	77,376	4,455

[1] Includes only that received in raw material form; excludes products made of graphite.
[2] Less than ½ unit.

WORLD REVIEW

World production of natural graphite increased slightly in 1973, but the gain was not sufficient either to overcome the decline of the previous year or to keep pace with the growing international market. Furthermore, a large part of the increase was in the amorphous form of graphite in Mexico and the Republic of Korea, while a crucial decline in output of the shortage-plagued crystalline graphite occurred in the Malagasy Republic. As a result, the overall situation in world markets was little changed from that which prevailed in 1972. Crystalline graphite remained in short supply and became increasingly costly, while supplies of amorphous graphite continued to be adequate.

India.—Plans to set up a graphite beneficiation plant in the Palamau district of Bihar State were announced by the Bihar Mineral Development Corp. No further details on the plant or its source of ore were given.[3]

Malagasy Republic.—Problems stemming from the continuing tense political climate in the country as a whole, and particularly in the graphite-producing region around Tamatave, caused a sharp drop in output during the year. Inability of the French-owned and relatively low-paying graphite mines to obtain sufficient labor was a major cause of the production decline and tended to discourage owners from undertaking needed expansion projects. Despite recurrent rumors, however, the government still showed no inclination to nationalize the industry. An additional serious difficulty arose when an ocean-shipping line refused to handle graphite shipments because of the risk of contaminating other cargo. Negotiations were under way at yearend, but the problem had not been resolved.[4]

Sri Lanka.—Production rose toward its former level as industry adjusted to government ownership. In addition, shipments to the United States became more regular, in contrast to the erratic pattern of receipts in 1972.

Other countries.—No further announcements were made concerning graphite discoveries near Niteroi, Brazil, and Razanj, Yugoslavia, that were reported a year ago, indicating that development of the deposits had not taken place.

[3] Industrial Minerals. Company News and Mineral Notes. No. 72, September 1973, p. 43.

[4] U.S. Department of State, Washington, D.C. Telegram 40350, Feb. 28, 1974, 2 pp.; and discussion with members of the graphite industry.

Table 7.—Graphite: World production by country

(Short tons)

Country [1]	1971	1972	1973 [p]
Argentina	162	[e] 165	[e] 165
Austria	23,581	20,693	18,972
Brazil	[r] 3,013	3,458	NA
Burma	168	239	NA
China, People's Republic of	33,000	33,000	33,000
Germany, West	[2] 13,986	12,509	NA
Italy	701	852	[e] 4,400
Japan	1,162	940	[e] 880
Korea, North [e]	[r] 85,000	[r] 85,000	85,000
Korea, Republic of	79,934	44,939	NA
Malagasy Republic	[r] 22,174	20,194	[e] 15,000
Mexico	56,125	60,748	[e] 65,000
Norway	[r] 9,136	9,540	[3] 7,711
Romania [e]	6,600	6,600	6,600
Sri Lanka	7,921	7,871	[e] 7,900
South Africa, Republic of	1,262	934	[e] 860
U.S.S.R. [e]	[r] 90,000	[r] 90,000	90,000
United States	W	W	W
Total	[r] 433,925	397,682	NA

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data.

[1] In addition to the countries listed, Czechoslovakia, India, Southern Rhodesia, and the Territory of South-West Africa produce graphite, but available information is inadequate to make reliable estimates of output levels.

[2] In part produced from imported crude graphite.

[3] Output of A/S Skaland Grafitverk only.

TECHNOLOGY

While research efforts continued to be concentrated on manufactured graphite and its uses in 1973, several new developments occurred either pertaining to natural graphite or applicable to both natural and manufactured graphite.

Graphite fluoride is one of many materials being studied as a solid lubricant and shows promise of being useful under high-temperature conditions. Tests of the wear life of graphite fluoride were described in a research report,[5] and a new product consisting of graphite fluoride with polyimide varnish as a binder was announced.[6] A new water-based forging lubricant, consisting primarily of graphite, was also described,[7] and the addition of graphite to an iron base cermet material will allow it to function in conditions of dry friction.[8]

The increasing importance of powder metallurgy was stressed in several speeches and articles during the year, with particular emphasis on its application to the automotive industry.[9] Much speculation centered on its possible use in parts for the new rotary engine.[10] Graphite is frequently used to supply the carbon in powdered steels. A research study of a powdered material containing graphite and tantalum carbide was also described.[11]

Also in the area of new materials, several processes for coating or impregnating graphite were announced.[12] These processes yielded graphites of higher strength and possibly improved resistance to oxidation. A patented refractory compound containing graphite, alumina, and silicon carbide, developed in Japan, was claimed to have good resistance to erosion, spalling, and oxidation.[13]

Fiber-reinforced composite materials once again held the center of attention for researchers in manufactured graphite during 1973. Graphite fiber costs dropped as low as the $40 to $50 per pound range, opening up new opportunities for commercial applications outside the aerospace field.[14] Improved types were also offered, including graphite ribbon.[15] However, research also moved forward on competing materials, and the future prospects of these graphitic materials remained uncertain.[16]

Graphite fiber composites have found several applications in the sporting goods area. Graphite golf club shafts have proved popular,[17] and graphite tennis racket frames are also in use. Racing car builders have taken advantage of the weight-reducing feature of composites in such components as wheels, bumpers, and dashboards,[18] and the horse racing industry has found an application for graphite shafts in sulky rigs.[19] Additional potential uses may be developed for various types of machinery.[20]

Numerous studies of new composite materials and processing methods were conducted. These studies covered a wide range of subjects including basic physical

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[5] Mecklenburg, Karl R., and B. D. Mc Connell. Graphite Fluoride: A Proposed Solid Lubricant. Midwest Res. Inst. Kansas City, Mo. April 1973, 49 pp.

[6] Materials Engineering. Materials Outlook. V. 77, No. 3, March 1973, p. 21.

[7] American Metal Market. Forging Lubricant Is Water-Based. V. 80, No. 113, June 11, 1973, p. 6.

[8] Wright-Patterson Air Force Base. Cermet Antifriction Material. Foreign Technol. Div., Dayton, Ohio, Apr. 30, 1973, 5 pp.

[9] American Metal Market. Sees Total '73 Use of Powdered Metals Up. V. 80, No. 138, July 17, 1973, p. 1.
———. Turbine Engines, Says GE Exec., Need New Metallurgical, Processing Methods. V. 80, No. 248, Dec. 24, 1973, p. 4.

[10] American Metal Market. Delco Moraine in Ohio to Build Rotors for GM's Wankel Engine. V. 80, No. 214, Nov. 5, 1973, p. 11.

[11] Los Alamos Scientific Laboratory. Special Graphites and Carbide-Graphite Composites Developed at LASL. Los Alamos, N.Mex., April 1973, 67 pp.

[12] Iron Age. Process Develops Super-Hard Surface on Graphite. V. 212, No. 19, Nov. 8, 1973, p. 23.
Materials Engineering. Applications Prove the Worth of High-Heat Resistant Plastics. V. 77, No. 2, February 1973, p. 41.
———. Want Tougher Carbon and Graphite? Try Metal or Ceramic Impregnation. V. 78, No. 3, September 1973, pp. 42–45.

[13] Refractory Institute. Patents of Possible Interest for Refractory Manufacturer. Oct. 16, 1973, p. 6.

[14] Chemical Engineering. RP Back on the Track. V. 80, No. 11, May 14, 1973, pp. 94, 96.
Materials Engineering. Graphite Fibers Are Down in Cost, Up in Performance. V. 77, No. 4, April 1973, p. 35.

[15] Pfizer, Inc. Research Study in Evaluation of Graphite Ribbon Composites. Easton, Pa., December 1972, 99 pp.

[16] Materials Engineering. Materials Outlook: Boron and Graphite Challenged for Future Engine Parts. V. 78, No. 6, November 1973, p. 19.

[17] Washington Post. Graphite Shaft Boosts Both Drives, Business Sec., Apr. 17, 1973.

[18] Iron Age. Graphite Gives Sub-Compact Cars the Racer's Edge. V. 211, No. 21, May 24, 1973, pp. 63–65.

[19] Materials Engineering. Materials Applications. V. 77, No. 3, March 1973, p. 22.

[20] Hercules, Inc. Hercules Annual Report 1973. P. 13.

analysis of graphite,[21] the properties obtained by combining various materials in composites,[22] and new methods of processing and fabrication.[23] The development of composites containing graphite and a metal continued to pose problems, but research results with aluminum looked promising.[24] One potential approach under study is that of bonding a graphite-epoxy composite to a metal.[25]

In addition to fibers and composites, other types of manufactured graphite materials were developed during the year. One was a carbon-graphite composition for use in making seal rings, bearings, and rotor vanes usable at elevated temperatures.[26] Other types were developed for mold materials in the casting of glass, ceramics, and metals.[27] A laminate containing steel, graphite and asbestos, which is expected to withstand the high temperatures of rocket nozzles, was also patented.[28] Finally, a product combining graphite ribbon with other forms of the material is expected to alleviate certain problems encountered in oxidative electrosyntheses.[29]

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21 Nature Physical Science. Two-Dimensional Lattice Orientation and Three-Dimensional Crystallinity in Carbon Fibers. V. 238, Aug. 28, 1972, pp. 137–39.

22 American Metal Market. LTV Awarded Air Force Pact for Graphite/Boron Wing Panels. V. 80, No. 141, July 20, 1973, p. 5.

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Metal Progress. Graphite-Polyimide Wing Box Box Beam Includes Titanium Parts. V. 103, No. 1, January 1973, p. 60.

23 Randolph, R. E., J. Witzel, J. N. Burns, H. L. Pritt, and J. C. Tsamisis. Graphite Composite Landing Gear Components—Side Brace Assembly and Torque Link for A37B Aircraft. Hercules, Inc., Magna, Utah, Bacchus Works, May 15, 1973, 150 pp.

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26 Materials Engineering. Machinable Carbon-Graphite Is Very Corrosion Resistant. V. 77, No. 6, June 1973, p. 49.

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Gypsum

By Avery H. Reed [1]

The gypsum industry continued to operate at record levels in 1973. Output of crude and calcined gypsum set new annual records. Imports were about the same as in 1972. Sales of gypsum products were a record 20.6 million tons.

American Cyanamid Co. planned to build a $16 million plant at Savannah, Ga., to recover byproduct gypsum from its ilmenite plant sludge wastes. The gypsum will be made into wallboard. The Flintkote Co. purchased the Florence, Colo., mine and plant of Johns-Manville Corp. Kaiser Gypsum Co. Inc. planned to expand its New Jersey and Florida plants 30%. National Gypsum Co. planned to build a $60 million wallboard plant at Wilmington, N.C.

Energy.—The Bureau of Mines completed a comprehensive canvass of energy used in the mineral industries in 1973. All gypsum mines and calcining plants were covered.

The canvass showed that the gypsum industry depended on the use of natural gas and petroleum products for most of its energy requirements. Neither coal nor coke was used. Only 7% of the total energy used was purchased electricity.

At gypsum mines, 51% of the energy used was from diesel fuel, and 38% was purchased electricity. Most of this was used by heavy excavating equipment. At calcining plants, 73% of the energy used was from natural gas and 15% was from heavy fuel oil. Most of this was used for heat in the calciners. Total energy used was 14.8 billion kilowatt-hours.

The gypsum industry used 35 billion cubic feet of natural gas, 51 million gallons of heavy fuel oil, 991 million kilowatt-hours of purchased electricity, 18 million gallons of diesel oil, 8 million gallons of liquefied petroleum gases (LPG), and 1 million gallons of gasoline. On a total energy basis, only 3% was used in mining.

Petroleum products required for mining crude gypsum were 392 gallons of diesel fuel, 49 gallons of heavy fuel oil, 29 gallons of gasoline, and 7 gallons of LPG for each thousand tons produced. For calcining gypsum requirements were 3,696 gallons of heavy fuel oil, 961 gallons of diesel oil, 566 gallons of propane, and 69 gallons of gasoline for each thousand tons of calcined gypsum produced. In addition, 2.6 million

[1] Supervisory physical scientist, Division of Nonmetallic Minerals—Mineral Supply.

Table 1.—Salient gypsum statistics
(Thousand short tons and thousand dollars)

	1969	1970	1971	1972	1973
United States:					
Active mines and plants [1]	114	108	107	108	112
Crude: [2]					
Mined	9,905	9,436	10,418	12,328	13,558
Value	38,354	35,132	39,057	48,504	56,650
Imports for consumption	5,858	6,128	6,094	7,718	7,661
Calcined:					
Produced	9,324	8,449	9,526	12,005	12,592
Value	143,466	132,047	151,991	195,862	205,326
Products sold (value)	414,880	353,474	435,257	560,569	632,809
Exports (value)	3,446	3,475	4,214	5,276	7,360
Imports for consumption (value)	14,602	16,581	16,332	22,042	21,937
World: Production	57,581	56,868	r 58,421	r 66,142	67,032

r Revised.
[1] Each mine, calcining plant, or combination mine and plant is counted as 1 establishment.
[2] Excludes byproduct gypsum.

Table 2.—Energy materials used by the gypsum industry in 1973

Source and unit	In mining	In calcining	Total
Natural gas million cubic feet	--	34,758	34,758
Heavy fuel oil thousand gallons	658	50,113	50,771
Electricity thousand kilowatt-hours	164,699	826,307	991,006
Diesel oil thousand gallons	5,320	13,030	18,350
LPG do	99	7,674	7,773
Gasoline do	397	939	1,336

cubic feet of natural gas was required per thousand tons calcined.

Cost of energy used in the gypsum industry was estimated at $2.3 million for mining and $30.8 million for calcining. Energy cost per ton of crude gypsum was estimated at $0.17 per ton; the cost per ton of calcined gypsum was $2.45.

Each ton of gypsum mined required 32 kilowatt-hours of energy, and each ton of gypsum calcined required 1,142 kilowatt-hours.

Table 3.—Energy materials required, per thousand tons of product, by the gypsum industry in 1973

Source and unit	In mining	In calcining
Natural gas thousand cubic feet	--	2,564
Heavy fuel oil gallons	49	3,696
Electricity kilowatt-hours	12,000	61,000
Diesel oil gallons	392	961
LPG do	7	566
Gasoline do	29	69

Table 4.—Energy used by the gypsum industry in 1973

(Thousand kilowatt-hours)

Source	In mining	Percent	In calcining	Percent	Total	Percent
Natural gas	--	--	10,496,916	73	10,496,916	71
Heavy fuel oil	28,859	7	2,197,901	15	2,226,760	15
Electricity	164,699	38	826,307	6	991,006	7
Diesel oil	216,183	51	529,486	4	745,669	5
LPG	3,801	1	294,612	2	298,413	2
Gasoline	14,534	3	34,377	--	48,911	--
Total	428,076	100	14,379,599	100	14,807,675	100

Table 5.—Cost of energy used in the gypsum industry in 1973

Activity	Gypsum produced (short tons)	Energy used				
		Thousand kilowatt hours	Kilowatt hours per short ton	Cost		
				Total cost	Per thousand kilowatt hours	Per short ton
Mining	13,557,973	428,076	32	$2,290,529	$5.35	$0.17
Calcining	12,591,586	14,379,599	1,142	30,842,050	2.15	2.45

DOMESTIC PRODUCTION

Thirty-nine companies mined crude gypsum at 69 mines in 22 States. Of these mines, 57 were open pit and 12 were underground mines. Crude output increased 10% to 13,558,000 tons, a new annual record. Leading States were Michigan, California, Texas, Iowa, and Oklahoma. These 5 States, with 29 mines, accounted for 60% of the total domestic production.

Leading companies were United States Gypsum Co. (13 mines), National Gypsum Co. (8 mines), Georgia-Pacific Corp. (7 mines), The Flintkote Co. (3 mines), and H. M. Holloway Inc. (1 mine). These 5 companies, operating 32 mines, produced 73% of the total output of crude gypsum. Leading individual mines were U.S. Gypsum's Plaster City mine in California, U.S. Gypsum's Alabaster mine in Michigan, National's Tawas City mine in Michigan, Holloway's Lost Hills mine in California, and U.S. Gypsum's Southard mine in Oklahoma. These five mines accounted for 26% of the national total.

Fourteen companies calcined gypsum at 76 plants in 30 States. Output was a record high of 12,592,000 tons, an increase of 5% over that of 1972. Leading States were Texas, California, New York, Iowa, and Indiana. These 5 States, with 29 plants, accounted for 44% of the total output.

Leading companies were U.S. Gypsum Co. (23 plants), National Gypsum Co. (19 plants), The Flintkote Co. (6 plants), Georgia-Pacific Corp. (10 plants), and Kaiser Cement & Gypsum Co. (5 plants). These 5 companies, operating 63 plants, accounted for 87% of the total domestic calcined output. Leading individual plants were U.S. Gypsum's Plaster City plant in California, Georgia-Pacific's Acme plant in Texas, U.S. Gypsum's Shoals plant in Indiana, Weyerhaeuser Co.'s Hot Springs plant in Arkansas, and U.S. Gypsum's Fort Dodge plant in Kansas. These five plants accounted for 14% of the national total.

Valley Nitrogen Producers Inc., Occidental Petroleum Corp., and Collier Carbon & Chemical Corp. sold 322,000 tons of byproduct gypsum valued at $1,931,000 for use in agriculture, in California.

The United States is the world's leading producer of gypsum, accounting for 20% of the total world output.

Table 6.—Crude gypsum mined in the United States, by State

(Thousand short tons and thousand dollars)

State	1972			1973		
	Active mines	Quantity	Value	Active mines	Quantity	Value
Arizona	4	W	W	4	158	669
California	5	1,525	4,965	5	1,778	5,834
Colorado	4	W	W	4	151	568
Iowa	5	1,380	5,714	5	1,470	6,324
Michigan	5	1,650	7,267	5	1,882	8,538
Nevada	3	860	2,871	4	1,154	3,662
New Mexico	3	W	W	3	255	1,220
New York	3	486	3,079	3	525	3,369
Oklahoma	8	1,196	3,888	7	1,429	5,796
South Dakota	1	24	43	1	W	W
Texas	7	1,542	5,284	7	1,616	6,469
Utah	2	W	W	3	231	1,134
Washington	1	5	13	1	W	W
Wyoming	3	W	W	3	312	1,348
Other States [1]	11	3,660	15,380	14	2,597	11,719
Total	65	12,328	48,504	69	13,558	56,650

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes Louisiana, Montana, and Virginia, 1 mine each; Arkansas, Idaho (1973), Indiana, Kansas (1972), and Ohio, 2 mines each; Kansas (1973), 3 mines.

Table 7.—Calcined gypsum produced in the United States, by State

(Thousand short tons and thousand dollars)

State	1972			1973		
	Active plants	Quantity	Value	Active plants	Quantity	Value
California	7	1,154	12,036	7	1,309	14,870
Florida	3	594	7,014	3	642	8,219
Georgia	3	702	12,984	3	699	12,370
Iowa	5	913	15,396	5	975	16,982
Michigan	4	536	10,640	4	596	11,677
Nevada	3	562	8,386	3	541	8,648
New Jersey	4	529	9,798	4	587	6,727
New York	7	1,138	21,214	7	1,230	20,931
Ohio	3	433	6,796	3	434	5,227
Texas	7	1,294	21,538	7	1,349	25,610
Other States [1]	30	4,150	70,060	30	4,230	74,065
Total	76	12,005	195,862	76	12,592	205,326

[1] Includes Arizona, Arkansas, Colorado, Connecticut, Delaware, Illinois, Massachusetts, Montana, New Hampshire, Pennsylvania, and Washington, 1 plant each; Kansas, Louisiana, Maryland, New Mexico, Oklahoma, Utah, Virginia, and Wyoming, 2 plants each; and Indiana, 3 plants.

CONSUMPTION AND USES

Apparent consumption of gypsum (production plus imports minus exports) was 21.2 million tons, an increase of 6% and a new annual record. Imports were 36% of the total apparent consumption.

Of the total gypsum sold or used, 5.7 million tons (28%) was uncalcined. Of the total uncalcined gypsum, 4.1 million tons (73%) was used for portland cement, and 1.5 million tons (25%) was used in agriculture. The leading sales regions for gypsum consumed in cement were the West South-Central and the Middle Atlantic, which accounted for 34% of the total. For agricultural gypsum, the Pacific sales region accounted for 84% of the total.

Table 8.—Gypsum products (made from domestic, imported, and byproduct gypsum) sold or used in the United States, by use

(Thousand short tons and thousand dollars)

Use	1972		1973	
	Quantity	Value	Quantity	Value
Uncalcined:				
Portland cement	3,924	19,405	4,148	22,189
Agriculture	1,146	5,970	1,453	7,402
Other	124	1,535	117	1,479
Total [1]	5,195	26,911	5,719	31,070
Calcined:				
Industrial plaster	299	10,657	353	14,181
Building plaster:				
Regular base coat	329	7,910	292	7,433
Mill-mixed base coat	178	5,707	166	5,607
Veneer plaster	98	5,713	88	5,366
Other [2]	235	5,928	224	5,558
Total [1]	841	25,258	771	23,964
Prefabricated products [3]	13,078	497,744	13,793	563,594
Total calcined	14,217	533,658	14,917	601,739
Grand total	19,412	560,569	20,636	632,809

[1] Data may not add to totals shown because of independent rounding.
[2] Includes gauging, molding, and Keene's cement, roof deck concrete, and other uses.
[3] Includes weight of paper, metal, or other materials.

Table 9.—Prefabricated products sold or used in the United States, by product

Product	1972			1973		
	Thousand square feet	Thousand short tons [1]	Value (thousands)	Thousand square feet	Thousand short tons [1]	Value (thousands)
Lath:						
⅜-inch	430,536	335	$12,792	351,987	272	$11,218
½-inch	18,004	17	596	16,168	15	553
Total [2]	448,540	352	13,388	368,155	286	11,771
Veneer base	357,443	316	13,521	399,373	368	15,710
Sheathing	337,084	319	12,024	337,443	323	12,921
Regular gypsumboard:						
⅜-inch	1,196,096	913	36,982	1,099,064	843	36,010
½-inch	9,083,662	8,291	291,961	9,570,318	8,582	326,133
⅝-inch	612,518	608	26,847	295,563	322	12,698
1 inch	19,528	37	1,844	25,158	50	2,414
Other [3]	135,894	109	4,794	109,495	97	4,193
Total [2]	11,047,698	9,958	362,428	11,099,598	9,893	381,448
Type X gypsumboard	1,783,677	1,939	75,466	2,574,516	2,721	116,401
Predecorated wallboard	195,360	178	19,274	214,369	191	22,900
Other	14,254	14	1,641	10,571	11	2,443
Grand total [2]	14,184,059	13,078	497,744	15,004,025	13,793	563,594

[1] Includes weight of paper, metal, or other material.
[2] Data may not add to totals shown because of independent rounding.
[3] Includes ¼-inch, 5/16-inch, and ¾-inch gypsumboard.

Of the total calcined gypsum, 92% was used for prefabricated products and 8% was used for plasters. Of the prefabricated products, 72% was regular wallboard, 20% was Type X wallboard, and 2% was lath.

The leading sales regions for prefabricated products were the South Atlantic and the East North-Central, which accounted for 36% of the total. For plaster, the East North-Central and the South Atlantic accounted for 48% of the total.

PRICES

The value of crude gypsum increased from $3.93 per ton in 1972 to $4.18. The value of calcined gypsum decreased from $16.32 in 1972 to $16.31. The average value of byproduct gypsum sold was $6 per ton.

The average value of gypsum products increased from $28.88 in 1972 to $30.67. Prefabricated products were valued at $40.86, plasters at $33.94, and uncalcined products at $5.43 per ton.

Quoted prices for gypsum are published monthly in the Engineering News-Record. Prices at yearend showed a wide range, based on delivered prices. Regular ½-inch wallboard prices ranged from $41 per thousand square feet at Dallas to $86 at Chicago.

FOREIGN TRADE

The gypsum industry depends on imports. Imports of crude gypsum from Canada (78%), Mexico (16%), Jamaica (4%), the Dominican Republic and Italy (2%), totaled 7.7 million tons and supplied 36% of domestic consumption. Exports of crude gypsum were 63,000 tons.

Table 10.—U.S. exports of gypsum and gypsum products

(Thousand short tons and thousand dollars)

Year	Crude, crushed, or calcined		Value of other manufactures n.e.c.	Total value
	Quantity	Value		
1971	49	2,318	1,896	**4,214**
1972	51	2,582	2,694	**5,276**
1973	63	3,135	4,225	**7,360**

Table 11.—U.S. imports for consumption of gypsum and gypsum products

(Thousand short tons and thousand dollars)

Year	Crude (including anhydrite)		Ground or calcined		Value of alabaster manufactures [1]	Value of other manufactures n.e.c.	Total value
	Quantity	Value	Quantity	Value			
1971	6,094	13,447	2	105	1,545	1,235	**16,332**
1972	7,718	18,342	2	152	1,950	1,598	**22,042**
1973	7,661	17,572	2	123	1,914	2,328	**21,937**

[1] Includes imports of jet manufactures, which are believed to be negligible.

Table 12.—U.S. imports for consumption of crude gypsum by country

(Thousand short tons and thousand dollars)

Country	1972		1973	
	Quantity	Value	Quantity	Value
Canada	5,912	13,946	5,944	14,100
Dominican Republic	116	371	177	648
Italy	15	6	([1])	9
Jamaica	439	1,292	334	867
Mexico	1,236	2,727	1,206	1,948
Total	7,718	18,342	7,661	17,572

[1] Less than ½ unit.

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Botswana.—Minerals Research Inc. planned to mine gypsum at Foley for use in cement. Deposits containing 3 million tons have been proved.

Canada.—Canada was the second leading producer of crude gypsum, accounting for 12% of the world total. Truroc Gypsum Products Ltd. planned to build a new wallboard plant at Vancouver.

France.—France was the third leading gypsum producer, accounting for 10% of the world total. Lambert Industries planned to build a new wallboard plant at Grand Quevilly.

Greece.—Reserves of gypsum in Greece amount to hundreds of millions of tons. They are located in the western part of the country, on the Ionian Islands, on Crete, and on some of the Dodecanese Islands.

Netherlands.—Rigips Baustoffwerke GmbH and the Dutch State Mines plan to build a wallboard plant at Born, using by-product phospho-gypsum.

Pakistan.—The West Pakistan Industrial Development Corp. announced the discovery of a 1-million-ton, 99% pure gypsum deposit near Sanghar.

Table 13.—Gypsum: World production, by country

(Thousand short tons)

Country [1]	1971	1972	1973 [p]
North America:			
Canada (shipments) [2]	6,702	8,099	8,316
Dominican Republic	[r] 273	[r] [e] 275	[e] 275
El Salvador [e]	7	7	7
Guatemala [e]	9	9	9
Honduras	[e] 11	17	[e] 20
Jamaica	341	486	393
Mexico	1,431	1,651	1,669
Nicaragua [2]	28	29	[e] 39
Trinidad and Tobago	[r] (3)	(4)	--
United States	10,418	12,328	13,558
South America:			
Argentina	[r] 559	560	560
Bolivia	[5] 2	[5] 3	[e] 3
Brazil [e]	320	320	320
Chile	168	192	141
Colombia	201	222	105
Paraguay	13	12	12
Peru	99	[e] 100	[e] 100
Venezuela [e]	110	110	110
Europe:			
Austria [2]	654	838	964
Belgium	106	117	[e] 150
Bulgaria	198	[e] 200	[e] 200
Czechoslovakia	528	552	573
France [2]	5,634	6,826	6,790
Germany, East	347	347	[e] 391
Germany, West (marketable)	1,756	1,971	1,889
Greece	[r] 358	441	[e] 450
Ireland	367	419	[e] 420
Italy	3,774	[e] 3,860	[e] 3,860
Luxembourg	6	5	6
Poland [e]	937	937	937
Portugal	[r] 196	149	187
Spain	4,443	[e] 4,520	[e] 4,520
Switzerland [e]	110	110	110
U.S.S.R. [e]	5,200	5,200	5,200
United Kingdom	4,600	4,590	4,066
Yugoslavia	276	298	309
Africa:			
Algeria [e]	193	193	193
Angola	[r] 28	92	51
Egypt, Arab Republic of	581	477	[e] 520
Ethiopia	4	5	--
Kenya [2]	101	[e] 110	[e] 110
Libya [e]	4	4	4
Niger	(3)	1,819	[e] 1,875
South Africa, Republic of	450	462	533
Sudan [2] [e]	2	2	2
Tanzania	20	20	14

See footnotes at end of table.

Table 13.—Gypsum: World production, by country—Continued

(Thousand short tons)

Country [1]	1971	1972	1973 p
Asia:			
Burma	13	16	17
China, People's Republic of e	606	661	661
Cyprus	r 10	13	e 13
India	1,199	1,218	974
Indonesia e	9	9	9
Iran [6]	2,480	2,646	e 2,700
Israel [7]	88	130	e 110
Japan	583	513	417
Jordan	26	33	33
Lebanon	41	e 44	e 44
Mongolia e	28	28	28
Pakistan	147	170	102
Philippines	47	94	112
Saudi Arabia	[8] 40	r e 50	50
Syrian Arab Republic e	17	17	17
Taiwan	18	7	6
Thailand	185	99	260
Turkey e	r 331	375	410
Vietnam, South e	8	8	8
Oceania: Australia	r 980	1,027	e 1,100
Total	r 58,421	66,142	67,032

e Estimate. p Preliminary. r Revised.

[1] Gypsum is also produced in Cuba and Romania, but available information is inadequate to make reliable estimates of output levels.

[2] Includes anhydrite.

[3] Less than ½ unit.

[4] Revised to zero.

[5] Net exports.

[6] Year ended March 20 of year following that stated.

[7] Year ended March 21 of year following that stated.

[8] Figure is for Hejira calendar year 1391, beginning February 27, 1971 and ending February 15, 1972.

U.S.S.R.—The U.S.S.R. ranked fourth in world gypsum output, accounting for 8% of the total.

United Kingdom.—The United Kingdom ranked fifth in world gypsum production with 6% of the total output.

TECHNOLOGY

United States Gypsum Co. developed a new process for granulating gypsum into granules of any size. A plant will be built at Sperry, Ohio, to make the new product. The gypsum will be compressed into sheet form, then broken up. The main use of the granules will be in agriculture. Farm use of gypsum has been limited owing to its fine texture which makes it difficult to handle and spread.

Helium

By Gordon W. Koelling [1]

Sales of high-purity helium (99.995% purity) in the United States during 1973 increased 2% to a total of 497 million cubic feet.[2] Approximately 36% of this total was sold by the Bureau of Mines and 64% was accounted for by private industry plant sales. Exports of high-purity helium, all by private industry, totaled 150 million cubic feet in 1973. The Bureau of Mines f.o.b. plant price for high-purity helium sold during the year remained at $35 per thousand cubic feet while private industry plant prices averaged $21 per thousand cubic feet.

In compliance with an order of the U.S. District Court for the District of Kansas issued on March 27, 1971, the Bureau of Mines continued to accept helium during 1972 under three of four conservation contracts whose termination provisions had been invoked by the U.S. Department of the Interior. This order rested on the ground that the Department had not filed an environmental impact statement on termination as required by the National Environmental Policy Act.

Following the release of an environmental impact statement by the U.S. Department of the Interior and an evaluation of the environmental consequences of terminating the contracts and careful consideration of options provided the Government under the contracts, the Secretary of the Interior, on February 2, 1973, issued notices terminating the three contracts in question. A further injunction against termination was granted by the District Court on the ground that the impact statement was unsatisfactory. The District Court order was reversed on appeal by the U.S. Court of Appeals for the Tenth Circuit in October 1973 and on November 12, 1973, the Department ceased the physical acceptance of helium for conservation storage. However, one of the companies involved in the litigation continued to deliver helium for 1 month to the Bureau of Mines for storage to its own account.

The issue of damages was pending in connection with a ruling made by the U.S. Court of Claims which held that the Government had materially breached its contract with the fourth contractor not involved in the above litigation.

DOMESTIC PRODUCTION

A total of 12 helium extraction plants were in operation during 1973. Of these, 2 were owned by the Federal Government and operated by the Bureau of Mines and 10 were owned by private industry.

Total helium extracted from natural gas during 1973 declined approximately 22% to 3,205 million cubic feet, despite a 3% increase in the output of high-purity helium to 647 million cubic feet. Approximately 80% of total helium extracted was crude helium[3] and 20% was high-purity helium produced for sale. About 93% of crude helium production and 72% of high purity output was from private industry plants producing for sale to commercial customers. The remaining 7% of crude and 28% of high-purity helium produced was extracted at Bureau of Mines plants.

Of the 357 million cubic feet of helium

[1] Geographer, Division of Fossil Fuels—Mineral Supply.
[2] All helium statistics in this chapter are reported in terms of contained helium measured at 14.7 pounds per square inch absolute and 70° F.
[3] Helium mixed with various quantities of other light gases, mostly nitrogen.

produced at the Bureau of Mines Keyes and Exell plants in 1973, approximately 83% was extracted from natural gas supplied by a private natural gas pipeline company on a gas processing contract basis. The remaining 17% was extracted from natural gas produced from the Bureau of Mines Cliffside gasfield primarily to create additional reservoir space for helium conservation storage. Almost all helium extraction from Cliffside natural gas occurred at the Exell plant.

Extensive modernization of the Exell plant was incomplete at the end of 1973 because of delays caused by technical problems. During the latter part of the year, the M. W. Kellog Co. submitted its engineering evaluation and recommendation of alternate concepts to correct purification deficiencies at unit IB. Kellog considered four concepts in its evaluation and recommended utilizing a pressure swing adsorption system in combination with the existing warm-end cold box equipment. This recommendation was under consideration at yearend. Kellog also completed engineering work for modifying enrichment unit IA and was planning to issue bid invitations for the necessary construction.

Table 1.—Helium extracted from natural gas in the United States
(Thousand cubic feet)

	1969	1970	1971	1972	1973 p
Crude helium: [1]					
Extracted at Bureau of Mines plants	306,200	429,400	504,406	r 262,197	175,976
Extracted at private industry plants	3,596,300	3,523,800	r 3,479,226	r 3,204,806	2,381,952
Total	3,902,500	3,953,200	r 3,983,632	3,467,003	2,557,928
High-purity helium: [2]					
Extracted at Bureau of Mines plants	360,700	230,700	173,626	r 173,526	180,114
Extracted at private industry plants	398,800	416,500	403,152	453,675	467,102
Total	759,500	647,200	576,778	r 627,201	647,216
Grand total	4,662,000	4,600,400	r 4,560,410	r 4,094,204	3,205,144

p Preliminary. r Revised.
[1] Excludes crude helium purified after interplant transfer.
[2] Includes only those quantities produced for sale; quantities entering conservation storage system after purification are included under crude helium.

Table 2.—Ownership and location of helium extraction plants in the United States, 1973

Category and owner or operator	Location	Type of production
Government owned:		
Bureau of Mines	Exell, Tex	Crude helium.
Do	Keyes, Okla	Crude and high-purity helium.
Private industry:		
Alamo Chemical-Gardner Cryogenics	Elkhart, Kans	High-purity helium.
Cities Service Cryogenics, Inc	Scott City, Kans	Crude helium.[1]
Cities Service Helex, Inc	Ulysses, Kans	Crude and high-purity helium.[2]
Kansas Refined Helium Co	Otis, Kans	High-purity helium.
Kerr-McGee, Corp	Navajo, Ariz	Do.
National Helium Corp	Liberal, Kans	Crude helium.
Northern Helex Co	Bushton, Kans	Do.[3]
Phillips Petroleum Co	Dumas, Tex	Do.
Do	Hansford County, Tex	Do.
Western Helium Co	do	High-purity helium.

[1] Output is piped to Cities Service Helex, Inc., plant at Ulysses, Kans., for purification.
[2] Purifies crude helium piped from Cities Service Cryogenics, Inc., plant at Scott City, Kans.
[3] Output is transported in highway semitrailers to other plants for purification.

Table 3.—Summary of Bureau of Mines helium plant and Amarillo shipping terminal operations

(Thousand cubic feet)

	1971	1972	1973 p
Supply:			
Inventory at beginning of period [1]	13,557	11,474	16,142
Helium extracted [2]:			
Exell plant:			
Crude	234,119	r 99,392	60,525
High purity [3]	50,304	--	--
Total Exell plant	284,423	r 99,392	60,525
Keyes plant:			
Crude	270,287	r 162,805	115,451
High purity [3]	123,322	r 176,469	181,334
Total Keyes plant	393,609	339,274	296,785
Total extracted	678,032	r 438,666	357,310
Helium returned in containers (net)	244	r 2,586	3,539
Total supply	691,833	r 452,726	376,991
Disposal:			
Sales of high-purity helium [3]	173,626	r 173,526	180,114
Net deliveries to helium conservation system [4]	506,733	r 263,058	188,245
Inventory at end of period [1]	11,474	16,142	8,632
Total disposal	691,833	r 452,726	376,991

p Preliminary. r Revised.
[1] At Exell and Keyes plants and at Amarillo shipping terminal.
[2] Excludes conservation helium produced from native gas withdrawal wells at Cliffside field which have been invaded by stored helium.
[3] Includes only those quantities produced for sale; quantities entering conservation after purification are included under crude helium.
[4] Excludes return of conservation helium produced as indicated in footnote 2 to conservation storage system.

CONSUMPTION AND USES

Domestic sales of high-purity helium rose only about 2% during 1973, considerably less than the 9% increase registered in 1972.

Bureau of Mines helium sales, which accounted for 36% of the domestic market increased at a slightly higher rate than total domestic sales in 1973. This was a moderate reversal of a 6-year declining trend in the need for helium by Federal agencies, which are required by law to purchase all of their major requirements from the U.S. Department of the Interior. The Bureau of Mines f.o.b. plant price, which is set at $35 per thousand cubic feet for the purpose of financing the long-range helium conservation program, was not competitive with the 1973 average private f.o.b. plant price of $21 per thousand cubic feet.

Approximately 41% of Bureau sales in 1973 were through purchases by Federal agencies from private distributors under General Services Administration contracts, which required the distributors to purchase equivalent quantities from the Bureau of Mines. These contracts made relatively small quantities of helium readily available to Federal installations and reduced freight charges for small purchases. The quantity of Bureau helium sales distributed in this manner increased 40% during 1973.

Domestic consumption of helium during 1973 was primarily for purging and pressurizing rockets and spacecraft, research, welding, maintenance of controlled atmospheres, leak detection, and cryogenics. Demand occurred principally in the States along the west and gulf coasts.

All helium sold by the Bureau of Mines was shipped in gaseous form in cylinders, highway semitrailers, or railway tank cars. Private industry plants shipped helium in both gaseous and liquid form. Much of the helium transported in liquid form was delivered by semitrailers and containerized dewars to distribution centers, where most of the product was gasified and compressed into small cylinders and trailers for delivery to consumers.

Table 4.—Total sales of high-purity helium in the United States
(Million cubic feet)

Year	Quantity
1969	[e] 670
1970	[e] 542
1971	447
1972	489
1973	[p] 497

[e] Estimate. [p] Preliminary.

Table 5.—Bureau of Mines sales of high-purity helium, by recipient
(Thousand cubic feet)

	1971	1972	1973 [p]
Federal agencies:			
Atomic Energy Commission	19,175	17,447	17,627
Department of Defense	82,355	[r] 61,578	47,766
National Aeronautics and Space Administration	32,905	35,775	34,739
National Weather Service	3,066	2,940	2,767
Other [1]	1,062	3,346	3,581
Total Federal agencies	138,563	[r] 121,086	106,480
Non-Federal customers [2]	35,063	52,440	73,634
Grand total	173,626	[r] 173,526	180,114

[p] Preliminary. [r] Revised.
[1] Includes quantities used by Bureau of Mines.
[2] Most of this was purchased in bulk by commercial firms, repackaged in smaller containers, and then sold to Federal installations under contract arrangements with the General Services Administration.

CONSERVATION

The purchase of crude helium by the Bureau of Mines, under the terms of contracts entered into with three private producers in 1961, continued during most of 1973 in compliance with court orders obtained during 1971 and early 1973 by Cities Service Helex, Inc., National Helium Corp., and Phillips Petroleum Co. As a result of the decision of the U.S. Court of Appeals for the Tenth Circuit in October, 1973, crude helium deliveries to the Bureau from Cities Service Helex, Inc., and National Helium Corp. ceased on November 12, 1973. However, Phillips Petroleum Co. opted to continue helium storage deliveries for its own account pending the outcome of negotiations on a long-term storage contract. These negotiations were unsuccessful and Phillips Petroleum Co. ceased deliveries for storage on December 12, 1973.

Helium held in the Bureau of Mines conservation storage system, which includes the conservation pipeline system and the partially depleted Cliffside gasfield near Amarillo, Tex., increased 7% during 1973 to a yearend total of 38,201 million cubic feet. Of this total, 97% was stored under the Bureau's conservation program (including that accepted under court order after March 28, 1971) and the remaining 3% was stored under contract for private producer's own accounts. Approximately 7% of the net addition to the helium conservation system in 1973 was accounted for by deliveries from Bureau plants, 89% was acquired from private industry plants for the conservation program, and 4% was added to storage under contract for private producers' own accounts.

Table 6.—Summary of Bureau of Mines helium conservation system[1] operations
(Thousand cubic feet)

	1971	1972	1973 p
Helium in conservation storage system at beginning of period:			
Stored under Bureau of Mines conservation program	28,118,119	31,635,937	34,628,600
Stored under contract for private producers' own accounts	58,972	r 527,113	1,002,314
Total	28,177,091	r 32,163,050	35,630,914
Input to system:			
Net deliveries from Bureau of Mines plants[2]	506,733	r 263,058	188,245
Acquired from private industry conservation plants	3,011,085	2,729,605	2,293,267
Stored under contract for private producers' own accounts	r 532,978	583,748	163,110
Total	r 4,050,796	r 3,576,411	2,644,622
Redelivery of helium stored under contract for private producers' own accounts	64,837	r 108,547	74,425
Net addition to system	r 3,985,959	r 3,467,864	2,570,197
Helium in conservation storage system at end of period:			
Stored under Bureau of Mines conservation program[3]	31,635,937	34,628,600	37,110,112
Stored under contract for private producers' own accounts	r 527,113	r 1,002,314	1,090,999
Total	r 32,163,050	35,630,914	38,201,111

p Preliminary. r Revised.
[1] Includes conservation pipeline system and Cliffside field.
[2] Excludes return to system of conservation helium produced from native gas withdrawal wells at Cliffside field which have been invaded by stored helium.
[3] Includes helium accepted under court order after March 28, 1971.

Table 7.—Helium purchased for Bureau of Mines conservation storage
(Thousand cubic feet)

Company	Helium delivered 1971	1972 r	1973 p
Cities Service Helex, Inc.[1]	741,902	699,048	515,862
National Helium Corp.[1]	1,165,251	1,107,898	1,011,238
Northern Helex, Co.[2]	147,463	--	--
Phillips Petroleum Co.[1]	956,469	922,659	766,167
Total	3,011,085	2,729,605	2,293,267

p Preliminary. r Revised.
[1] Deliveries from these companies between 8:00 a.m., Mar. 28, 1971, and 8:00 a.m., Nov. 12, 1973, accepted in compliance with orders issued by the U.S. District Court for the District of Kansas.
[2] This company ceased delivery of helium for Bureau of Mines conservation program as of 8:00 a.m. Mar. 28, 1971.

Table 8.—Deliveries of crude helium from private industry conservation plants to Bureau of Mines conservation storage system, 1973
(Thousand cubic feet)

Owner	Plant location	Delivered for Bureau of Mines conservation storage	Stored for companies' own accounts in Bureau of Mines conservation system: Delivered	Withdrawn	Net	Total
Cities Service Helex, Inc	Ulysses, Kans	515,862	[1] 71,411	[1] 59,834	11,577	527,439
National Helium Corp	Liberal, Kans	1,011,238	94	--	94	1,011,332
Phillips Petroleum Co	Dumas, Tex	439,115	91,605	14,591	77,014	843,181
	Hansford County, Tex	327,052				
Total		2,293,267	163,110	74,425	88,685	2,381,952

[1] Includes some helium stored for the account of Cities Service Cryogenics, Inc., which pipes its output to Cities Service Helex, Inc., for purification.

RESOURCES

Proved and probable helium reserves (in natural gas with a minimum helium content of 0.3%) in the United States, exclusive of those quantities in conservation storage at the Cliffside field, were estimated at 114,090 and 41,298 million cubic feet respectively, as of December 31, 1973. The total 155,388 million cubic feet of proved and probable reserves available at yearend was 14% higher than at the beginning of the year. This increase resulted entirely from revisions to probable reserves.

Although proved and probable helium reserves were contained in the natural gas reservoirs of 86 gasfields located in 10 States, the bulk of reserves were in four fields: the Greenwood field in Kansas and Colorado; the Hugoton field in Kansas, Oklahoma, and Texas; the Keyes field in Oklahoma; and the West Panhandle field in Texas. Almost 66% of proved and probable reserves were in fields being produced at yearend 1973. Approximately 38% of the helium-rich (0.3% helium content) natural gas produced was being processed for helium extraction, and helium contained in the remaining helium-rich natural gas output was being wasted incident to the consumption of the gas.

The Bureau of Mines continued its efforts to identify helium resources in the United States and other parts of the world. A total of 348 natural gas samples from 17 States and Australia were collected and analyzed for helium content during 1973. None of these samples indicated the occurrence of significant helium resources.

FOREIGN TRADE

Exports of high-purity helium in 1973 increased almost 9% and comprised 23% of the U.S. helium industry's total high purity sales compared with 22% during 1972. All exports were from private industry extraction plants which depended on foreign markets for 32% of their total high purity sales in 1973. Most of the quantity shipped was destined for Western Europe.

Table 9.—Exports of high-purity helium from the United States

(Million cubic feet)

Year	Quantity
1969	e 90
1970	e 105
1971	130
1972	138
1973	p 150

e Estimate. p Preliminary.

WORLD REVIEW

Helium produced outside the United States during 1973 totaled an estimated 132 million cubic feet. Canada produced approximately 35 million cubic feet from a single plant in Saskatchewan, mostly for export to Japan and other Asian countries, although some was used in Canada. A plant in France produced about 7 million cubic feet of helium as a byproduct of nitrogen removal operations. The countries of Eastern Europe extracted an estimated 90 million cubic feet during the year.

During 1973, Petrocarbon Developments, Ltd., of the United Kingdom began construction, under contract, of a helium and nitrogen extraction plant in Poland. This plant will separate helium and nitrogen from natural gas which has about a 45% nitrogen content. A helium purification and liquefaction unit to be integrated with the nitrogen removal process will have a high-purity helium output capacity of 150 million cubic feet per year. Completion of this project was expected by 1975.

TECHNOLOGY

During 1973 the world's largest containerized liquid helium dewar was placed in service. This dewar, designed and built by the Gardner Cryogenics Division of Carpenter Technology Corp., has a capacity of 11,000 gallons of liquid helium (approximately 1.1 million cubic feet of gas equivalent) as compared with an 8,500-gallon capacity (approximately 860,000 cubic feet of gas equivalent) of the largest units previously placed in service. At yearend several additional 11,000-gallon dewars were under construction.

Gulf General Atomic Co., a subsidiary of Gulf Oil Corp., continued work on a preliminary planning study of a helium gas-turbine for the Atomic Energy Commission. This study will assess the commercial feasibility of developing a helium-cooled nuclear reactor and employing the same helium in a closed cycle to drive the gas-turbine generator. This would eliminate the steam-turbine cycle ordinarily used in powerplants and allow heat rejection to take place directly to air in dry cooling towers, thereby eliminating thermal pollution of streams and allowing utility companies more flexibility in picking powerplant sites. The gas turbines themselves could be located inside the same containment vessel that housed the reactor core, thus offering a capital cost savings.

Iron Ore

By F. L. Klinger [1]

With strong demand for iron and steel throughout 1973, world production of iron ore increased to an estimated 850 million long tons,[2] about 11% more than in 1972. The increase in world exports was estimated at 15% to 20%, with major increases reported from Australia and Brazil. Imports of iron ore by Japan, the European Economic Community (EEC), and the United States totaled 133 million tons, 117 million tons, and 43 million tons, respectively, and consumption in most industrialized countries rose to record levels.

World output of pellets was estimated at 150 million tons, about 18% more than in 1972, and continued rapid growth in this sector was expected. New pellet plants were completed, under construction, or contracted for in more than a dozen countries in 1973. Several new direct-reduction projects were also begun, notably in fuel-rich countries such as Iran, Venezuela, and Saudi Arabia.

Large beneficiation plants based on flotation or high-intensity magnetic separation came on stream in Canada and Brazil. These installations were the first commercial-scale plants of their kind. Another large flotation plant was due to begin production in the United States in 1974.

Iron ore prices in most countries increased during 1973. Increases in contract prices allowed by Japanese buyers ranged from about 10% to 15% and were made retroactive to April 1, 1973. The increases were allowed mainly to compensate for devaluations of the U.S. dollar in 1971 and 1973. By yearend, indications were that prices would rise further in 1974.

In transportation of iron ore, the average size of vessels and individual cargoes continued to increase on the Great Lakes as well as in ocean trade. The largest ocean cargo was 218,000 tons. A second port facility capable of accommodating 250,000-ton carriers was completed in Brazil, and a new receiving terminal capable of handling 100,000-ton vessels was completed in the United Kingdom. Ocean freight rates continued to rise during most of 1973; some reduction was apparent by yearend, but rising fuel costs due to large increases in crude oil prices were expected to drive freight rates still higher in 1974.

[1] Physical scientist, Division of Ferrous Metals—Mineral Supply.

[2] Unless otherwise specified, the unit of weight used in this chapter is the long ton of 2,240 pounds.

Table 1.—Salient iron ore statistics

(Thousand long tons and thousand dollars)

	1969	1970	1971	1972	1973
United States:					
Iron ore (usable[1] less than 5% Mn):					
Production[2]	88,328	89,760	80,762	75,434	87,669
Shipments[3]	89,854	87,176	77,106	77,884	90,654
Value[3]	929,293	941,738	891,001	950,365	1,163,710
Average value at mines per ton	10.34	10.80	11.55	12.20	12.84
Exports	5,160	5,492	3,061	2,095	2,747
Value	62,310	67,898	38,147	26,776	37,922
Imports for consumption	40,732	44,891	40,124	35,761	43,296
Value	402,178	479,518	450,644	415,934	533,488
Consumption (iron ore and agglomerates)	140,235	131,571	116,196	126,943	146,922
Stocks Dec. 31:					
At mines	13,566	15,316	17,653	14,679	10,876
At consuming plants	50,935	52,781	57,738	50,061	45,990
At U.S. docks	2,648	3,403	3,424	2,612	3,053
Manganiferous iron ore (5% to 35% Mn):					
Shipments	385	329	177	131	181
World: Production	701,495	757,013	r 774,677	r 766,150	850,725

r Revised.

[1] Direct shipping ore, concentrates, agglomerates, and byproduct ore (mainly pyrite cinder and agglomerates).

[2] Includes byproduct ore.

[3] Excludes byproduct ore.

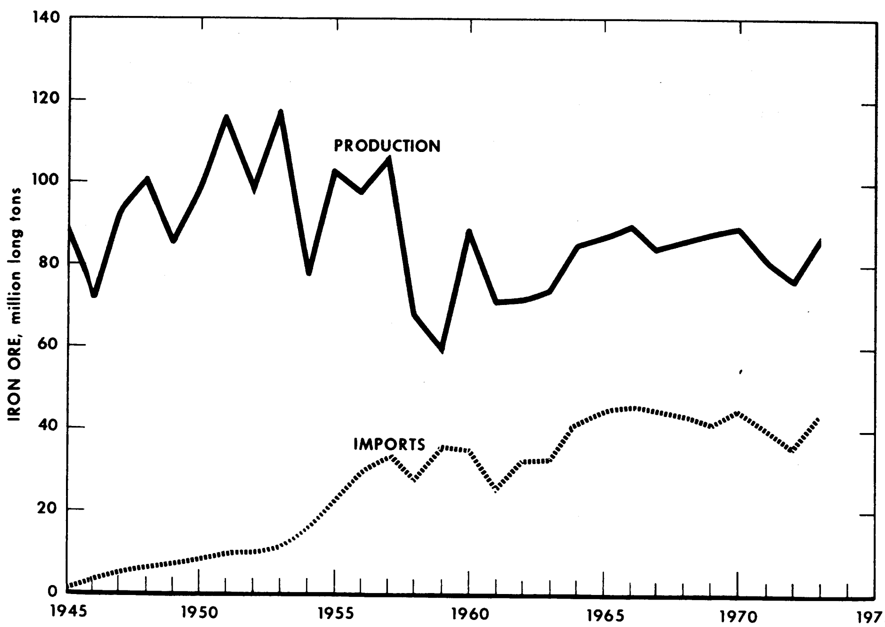

Figure 1.—United States iron ore production and imports for consumption.

EMPLOYMENT

Due to changes in procedures of reporting or tabulation of statistics, aggregate data on employment at U.S. iron ore mines and mills in 1973 were not comparable to data reported for 1972. Consequently, publication of employment statistics for 1973 will be deferred until these differences can be resolved.

DOMESTIC PRODUCTION

As a result of strong demand for iron and steel, and a relatively low level of iron ore stocks at the beginning of 1973, U.S. mine production of usable ore increased to 87.7 million tons, 16% more than in 1972 and the highest since 1970. Mine shipments exceeded production by 3 million tons and were the highest since 1957. Vessel shipments of iron ore from U.S. ports on the Great Lakes in 1973 totaled 73.8 million tons, an increase of 10.2 million tons compared with those of 1972.

Pellets made up 70% of mine production and shipments of iron ore in 1973. Although the proportion was slightly less than in 1972, the actual output of pellets increased by 14% in 1973 to 61.2 million tons. Shipments of pellets totaled 63.7 million tons. Most of the increase in production came from the Minntac plant in Minnesota.

Production of crude ore in 1973 totaled 218.7 million tons, of which 95.6% was produced from 59 open pit mines and 4.4% was produced from 7 underground mines. The proportion of direct-shipping ore continued to decline and made up only 1.7% of the total output. The average iron content of crude ore produced was estimated at 33.9%. The average iron content of all usable ore produced was slightly higher than 60.5%, ranging from about 55% in direct-shipping ore and concentrates to about 63% in pellets. Nationwide, the ratio of crude ore mined to usable ore produced in 1973 (excluding byproduct ore) was approximately 2.50:1, the same as in 1972.

The Lake Superior district accounted for 84% of all crude ore mined in 1973 and 82.6% of all usable ore produced. Minnesota produced 68% of the total usable ore; Michigan produced 13% and the remainder was produced in 18 other States. Five mines were closed by yearend: two in Alabama and one each in Minnesota, Pennsylvania and North Carolina.

In Minnesota, production of iron ore pellets totaled 41.6 million tons in 1973, a 20% increase compared with 1972. The increase was mainly due to the first full year of production from new facilities at the Minntac operation of United States Steel Corp. Production capacity at Minntac was raised to 12 million tons per year in mid-1972. In mid-1973, Bethlehem Steel Corp. and Pickands Mather & Co. (PM) announced plans to construct a taconite mining and processing complex near Hibbing by 1977. Initial production capacity of the facility will be 5.4 million tons of pellets per year. Cost of the project, which was expected to employ more than 1,000 persons during the construction period, was estimated at $150 million. The Mahoning natural-ore mine was closed by PM in August due to exhaustion of ore reserves. The mine formed part of the famous Hull-Rust-Mahoning open pit and had been in almost continuous production since 1895. Also near Hibbing, the Hanna Mining Co. began stripping operations at the Whitney natural-ore mine in 1973. Ore from the Whitney mine will be processed at the Pierce concentrator. The Pierce mine was expected to be closed in 1974. Near Eveleth, nominal production capacity for iron ore pellets at the Fairlane plant of Eveleth Taconite Co. was increased about 10% to 2.4 million tons annually. On the western Mesabi range, parts of the Trout Lake concentrator were being dismantled and the plant was expected to be inactive in 1974. In the suit filed against Reserve Mining Co. by the U.S. Department of Justice, alleging pollution of Lake Superior by taconite tailings discharged from the company's Silver Bay plant, trial began in the U.S. District Court at Minneapolis on August 1, 1973. The trial continued into 1974.

In Michigan, construction of the Tilden taconite facility was continued. The project is designed to produce 4 million tons of pellets per year from 10 million tons of low-grade hematite ore. Production was scheduled to begin by the fall of 1974. At the Empire magnetic taconite facility, expansion of production capacity to 5.2 million tons of pellets per year was expected to be completed by mid-1974. Both projects are managed by The Cleveland-Cliffs Iron Co.

In Pennsylvania, the Cornwall mine near Lebanon was finally closed by Bethlehem Steel Corp. in 1973 after the open pit ore was mined out. The underground portion of the mine was closed in 1972. The mine was the oldest operating iron mine in the United States, having been in continuous production since 1742. During that time about 100 million tons of ore were produced.

In Alabama, production of brown-ore concentrates was terminated by two companies, due to lack of adequate markets. The Blackburn mine and plant, operated by Shook & Fletcher Supply Co. near Russellville in Franklin County, were apparently closed late in 1972. Davis Mining Co. stopped mining in Crenshaw County in mid-1973. United States Pipe and Foundry Co. continued to operate the Russellville No. 15 mine in Franklin County and appeared to be the only remaining producer of iron ore in Alabama.

In North Carolina, the Cranberry mine and concentrator in Avery County were closed at yearend by Greenback Industries, Inc. This operation had produced small quantities of high-purity magnetite concentrate which was partly used as heavy-media material and partly in manufacture of ferrites.

CONSUMPTION

Consumption of iron ore and agglomerates in 1973 was 15.7% more than in 1972 and was the highest on record. Of the total quantity, 98.2% was consumed in blast furnaces, 1.4% was consumed in steelmaking furnaces, and 0.4% was used for manufacture of miscellaneous products consisting mostly of cement and heavy-media materials. Consumption in steelmaking furnaces increased for the first time in several years; this appeared to be due mainly to a 14% increase in output of open-hearth steel in 1973 as compared with 1972. Consumption in blast furnaces increased 15.5%. In blast furnaces, the weight ratio of iron ore and agglomerates consumed to hot metal produced was approximately 1.58:1 in 1973, compared with 1.55 in 1972.

Pellets made up about 52% of all iron ore and agglomerates consumed in 1973, and 65.5% of all agglomerates consumed. The respective shares contributed by domestically produced pellets were 44% and 56%. These proportions were essentially the same as in 1972.

Consumption data are shown in tables 10 and 11. In these tables, iron ore concentrate used to produce pellets and other agglomerates at mine sites is not reported as iron ore consumed; its consumption was reported only when such agglomerate was shipped to the furnace site and used (table 10). Iron ore concentrates and fines used to produce agglomerates (such as sinter) at iron and steel plants is reported as iron ore consumed (table 11), and consumption of agglomerates derived from this source is included in table 10. In table 11, the difference in weight between iron ore consumed and agglomerate produced is due to additives such as mill scale, flue dust, lime, coke, and other materials.

STOCKS

Stocks of iron ore and agglomerates at U.S. mines, docks, and consuming plants totaled 59.9 million tons on December 31, 1973. The total was 11% less than a year earlier and was the lowest since 1956. Yearend stocks represented about a 5-month supply at the average rate of consumption in 1973. The 49 million tons on hand at U.S. docks and consuming plants at yearend included 30 million tons of domestic ores, 8.5 million tons of Canadian ores, and 10.5 million tons of other foreign ores.

PRICES

Published prices for Lake Superior iron ores increased in 1973. In March, prices for natural ores rose by 20 cents per gross ton and the price of iron ore pellets rose by 0.3 cent per long ton unit of iron, compared to the prices in effect on January 1. At the beginning of the 1973 lake shipping season, prices for natural ores, per gross ton, basis 51.5% Fe natural, delivered rail-of-vessel at lower lake ports, were: Mesabi non-Bessemer, $11.91; Mesabi Bessemer, $12.06; Old Range non-Bessemer, $12.16; and Old Range Bessemer, $12.31. The price of iron ore pellets was 29.4 cents per long ton unit of contained iron. These prices were 5% to 6.6% higher than those in effect 1 year earlier. Any increase in transportation or handling costs was to be borne by the buyer.

Effective October 1, 1973, the price of iron ore pellets delivered to Lake Erie ports by the Hanna Mining Co. was increased 2.2%, to 30.019 cents per long ton unit of contained iron. Prices for natural ores marketed by the company were unchanged.

The average value (f.o.b. mine or concentrating plant) of usable iron ore shipped from domestic mines in 1973 was $12.84 per long ton compared with $12.20 in 1972 and $11.55 in 1971. These values were calculated from producers' statements and approximated the commercial selling price less the cost of mine-to-market transportation.

Prices for most foreign iron ores during the first half of 1973 appeared to be unchanged or only slightly higher compared with 1972 levels. Exceptions to this were evident in Sweden, where the average export price in 1973 was 7% less than 1972, and in Canada and Venezuela where the value of iron ore exported to the United States increased due to the rise in U.S. Lake Superior prices.

Strong pressure for upward revision of foreign prices was generated by devaluation of the U.S. dollar in February, as most prices for foreign ores are quoted in dollars. By November, Japanese buyers had agreed to raise the prices stipulated in many contracts with foreign ore producers, retroactive to April 1, 1973. Compared with contract prices prevailing in the first quarter, the increases averaged about 13% for Indian ores and 15% for Australian and Brazilian ores.

Nominal prices quoted for certain foreign iron ores at Atlantic ports late in 1973[3] were about 20% higher than prices quoted earlier in the year. The price of Swedish pellets, basis 68% Fe, rose from $14.25 per ton to $17.00 per ton. Brazilian iron ore, basis 68% to 69% Fe, increased from $10.00 per long ton to $12.00.

Revised 1973 f.o.b. prices for iron ore products under Japanese contracts[4] indicated ranges as follows (dry long ton basis): For run-of-mine ore, 60% to 66% Fe, $8.96 to $9.75; for lump ore (including sized lump), 64% to 65% Fe, $10.35 to $11.60; 60% to 62% Fe, $6.40 to $6.80 (India) to $7.50 to $8.12 (Chile) to $10.13 (Australia); for fines, 64% to 66% Fe, $5.25 to $8.68; 60% to 62% Fe, $5.45 to $8.40; 57% Fe, $4.40 to $5.88; for iron sand concentrates, 59% to 60% Fe and 6% to 7% TiO_2, $6.10 to $6.65; for iron ore pellets, per dry long ton unit of contained Fe, 21.5 to 24.3 cents (Australia), 19.3 cents (India), and 25.35 cents (Canada).[5]

TRANSPORTATION

The iron ore shipping season on the Great Lakes started relatively early in 1973. Vessel shipments from most U.S. ports had begun by April 2. By yearend, nearly 65 million gross tons of ore had passed through the Soo Locks compared with 54.3 million tons during 1972. All lake shipments totaled about 74 million tons in 1973.

With strong demand for ore at consuming centers, and continued aids to winter navigation, shipments from all U.S. ports continued beyond normal closing dates for the season. Shipments of ore were made in January from all ports except Duluth, Minn., and the last cargo of the season left Two Harbors, Minn., on February 5. Navigational aids in the winter of 1973–74 included, for the first time, daily ice-distribution maps delivered electronically to vessels. The maps were images obtained from aerial surveys using side-looking radar.

Lake freight rates at the start of the 1973 shipping season were about 9% higher than those in effect 1 year earlier although less than half of this increase took place in 1973. Basic rates in effect in March 1973 were as follows, per gross ton: from the head of the lakes to lower lake ports, $2.45; from Marquette, Mich., to lower lake ports, $2.20; from Escanaba, Mich., to Lake Erie ports, $1.84; and from Escanaba to lower Lake Michigan ports, $1.47. No further increases were reported by yearend. Handling charges at discharging ports during the 1973 season were 5% to 6% higher than 1 year earlier, but charges at upper lake ports were unchanged.

Some statistics on lake shipments of iron ore, by port, during the 1973 season are shown in the following tabulation.

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[3] American Metal Market. Dec. 27, 1973, p. 10.

[4] The TEX Report Co. Ltd. (Tokyo). Iron Ore Import '73. Pages 67–180.

[5] Dry long ton unit assumed to apply to pellet contracts with all Australian producers although specified only for Hamersley pellets. Figure for India estimated from price stated per dry metric ton.

Lake shipping port	Number of vessels loaded	Total tonnage shipped [1] (thousand long tons)	Average cargo (long tons [2])	Largest cargo (long tons [2])
Duluth, Minn	1,176	17,941	15,300	26,800
Taconite Harbor, Minn.[3]	569	13,104	23,000	58,200
Superior, Wis.[3]	642	11,951	18,600	31,200
Silver Bay, Minn.[3]	651	11,042	17,000	30,700
Escanaba, Mich.[3]	564	8,970	15,900	31,600
Two Harbors, Minn.[3]	400	7,790	19,500	51,000
Marquette, Mich.[3]	204	3,434	16,800	26,000
Total	4,206	74,232	XX	XX

XX Not applicable.
[1] Rounded to nearest 1,000 tons.
[2] Rounded to nearest 100 tons.
[3] Includes shipments in early 1974.

Principal source: Skillings' Mining Review, various issues, 1973 and 1974.

Rail freight rates for iron ore at the beginning of the 1973 shipping season on the Great Lakes were 4% to 6% higher than those in effect 1 year earlier. Some published rates[6] for selected routes were as follows (per gross ton): From Mesabi and Cuyuna ranges to Two Harbors, Minn., and Superior, Wis., $1.92; for pellets from McKinley and Mt. Iron, Minn., to Duluth, Minn., $1.70; for pellets from Marquette range to Escanaba, Mich., $0.95. The freight rate from Lake Erie ports to the Pittsburgh and Wheeling districts was $3.69 and that from Baltimore to the Pittsburgh district was $5.30. Rates for all-rail hauls from mines to consuming districts included Mesabi range to Chicago $6.98 and to the Pittsburgh and Wheeling districts, $13.91; Marquette and Menominee ranges to Chicago, $5.68, and to the Pittsburgh district $11.40; Pea Ridge, Mo., to Chicago $4.76; Black River Falls, Wis., to Chicago, $2.85; and Benson Mines, N.Y., to Cleveland, $6.48. No further increases were reported by yearend.

The size of ore-carrying vessels and the efficiency of materials handling systems on the Great Lakes continued to increase. The 1,000-foot, self-unloading tug-barge unit "Presque Isle," with cargo capacity of up to 59,000 gross tons of iron ore pellets, began service on December 16. The vessel will be used to transport pellets between Two Harbors, Minn., and the Gary, Ind., works of United States Steel Corp. Two 1,000-foot self-unloading bulk carriers were ordered in November by Pickands Mather & Co. The vessels were scheduled for delivery in 1976 and 1977 and will cost a total of about $75 million. The *Stewart J. Cort* and *Roger Blough*, having cargo capacities of up to 59,000 tons and 45,000 tons, respectively, transported a total of about 4.5 million tons of iron ore pellets on the lakes in 1973. Other new self-unloaders with cargo capacities ranging between 27,000 to 35,000 tons began service or were under construction. Other carriers were being lengthened to increase cargo capacity up to 28%.

Improved storage and materials handling facilities for iron ore and limestone were completed early in 1973 at the port of Conneaut, Ohio, by Pittsburgh & Conneaut Dock Co. The new facilities include a storage area for up to 3.2 million tons of material, a traveling stacker capable of stockpiling 10,000 tons per hour (tph), and two bucket-wheel reclaimers having a combined handling capacity of 5,000 tph. The system has an annual throughput capacity of 9.1 million tons in-and-out of storage. Formerly, there was little storage space and all iron ore had to be loaded directly into railway cars from the vessels. This required close scheduling of car availability with vessel arrivals and resulted in a heavy concentration of cars during 8 months of the year which caused traffic congestion during vessel delays.

In July, the Burlington Northern Railway Co. began a unit train operation between Hibbing, Minn., and Minnequa. Colo., a round-trip distance of about 2,400 miles. Trains of 110 cars, carrying 6,000 tons of iron ore, were scheduled to leave Hibbing every 173 hours. Initial plans called for shipment of 80,000 tons. The ore came from the Sherman mine and was destined for CF & I Steel Corp. Burlington Northern

[6] Skillings' Mining Review. V. 62, No. 51, Dec. 22, 1973, p. 2.

was also planning to expand its ore-handling facilities at Allouez, Wis., to accommodate future shipments of pellets from the new taconite project at Hibbing.

In foreign transport developments, shipments of iron ore began in November from the Minerações Brasileiras Reunidas (MBR) terminal at Guaiba Island in Sepetiba Bay, Brazil. The initial shipment was a cargo of 155,000 tons. The facility can load vessels of up to 300,000 deadweight tons (dwt) at rates up to 7,000 tons per hour. In Norway, bids were invited by the Swedish firm of Luossavaara-Kiirunavaara AB (LKAB) for expansion of iron ore shipping facilities at Narvik. Plans were to increase the maximum loading rate to 11,000 tph (7,200 tph for pellets) and to accommodate vessels of up to 400,000 dwt. In the United Kingdom, the Redcar iron ore terminal at Teesside was completed by the British Steel Corporation. The terminal can accommodate vessels up to 150,000 dwt and received its first 100,000-ton cargo of pellets in September. At other receiving ports, 13.8 million tons of iron ore were unloaded at Rotterdam (Europoort) in 1973, mostly for transshipment to West Germany. The largest incoming cargo was 151,000 long tons. About 3.4 million tons were unloaded at Port Talbot including one cargo of 105,000 tons.

Some statistics on foreign shipments of iron ore, by port, in 1973 are shown in the following tabulation.

Ocean shipping port	Number of vessels loaded	Total tonnage shipped (thousand long tons)	Average cargo (long tons [1])	Largest cargo (long tons [1])
Tubarão, Brazil	602	40,541	67,000	218,000
Port Hedland, Australia	458	34,785	76,000	138,000
Dampier, Australia	314	27,267	87,000	157,000
Narvik, Norway	634	22,900	37,000	106,000
Sept-Îles, Canada [2]	666	20,353	31,000	139,000
Puerto Ordaz, Venezuela	497	18,899	38,000	NA
Buchanan, Liberia	NA	12,584	NA	NA
Monrovia, Liberia	[3] 225	12,427	([3])	NA
Mormugao, India	NA	12,382	NA	NA
Nouadhibou, Mauritania [4]	296	10,168	34,000	NA
San Nicolas, Peru	138	9,041	65,000	143,000
Port Cartier, Canada [4]	237	8,806	37,000	139,000
Cape Lambert, Australia	107	8,338	78,000	NA
Porto Salazar, Angola	118	6,134	52,000	148,000

NA Not available.
[1] Rounded to nearest 1,000 tons.
[2] Includes shipments via St. Lawrence Seaway.
[3] Excludes shipments by Liberia Mining Co. (LMC), for which data were not available. Total tonnage shipped includes IMC.
[4] Also known as Port Etienne or Point Central.

Principal source: Skillings' Mining Review, various issues, 1974.

Ocean-freight rates for iron ore continued to increase in 1973, partly because of devaluation of the dollar and increased demand for iron ore and other bulk commodities, and partly because a large number of vessels were occupied in the grain trade, particularly between the United States and the Soviet Union. Although freight rates for most of the iron ore shipped by sea were probably controlled under long-term contracts, spot rates published in various issues of "Metal Bulletin" indicated that freight charges for individual shipments in 1973 were often 40% to 75% higher than those charged for similar shipments late in 1972, and some were two to three times higher. There was a sharp drop in rates for some shipments of iron ore from South America and West Africa late in 1973, when the Arab oil embargoes increased the number of vessels available for dry cargo trade, but in general the rates remained much higher than those of late 1972.

Late in 1973, published freight rates for individual shipments of iron ore to West European and Japanese destinations showed the following approximate ranges: To West Europe from Brazil and Canada, $7.50 to $11.00 per ton for cargoes of 28,000 to 135,000 tons; from Venezuela, $12.50 to $14.00 per ton for cargoes of 34,000 to 40,000 tons; from West Africa, $5.00 to $9.00 per ton for cargoes of 55,000 to

90,000 tons; and from Australia, $11.00 to $12.00 per ton for cargoes of 50,000 to 110,000 tons; to Japan from Australia, $9.00 to $11.00 for cargoes of 110,000 to 137,000 tons; from Brazil, $15.50 for 95,000 tons; from Liberia, $16.75 for 57,000 tons; and from eastern Canada, $14.25 for 140,000 tons.[7] Published freight rates under some Japanese long-term contracts[8] ranged from about $4.00 to $8.00 per ton for Brazilian ore (vessels of 50,000 to 125,000 dwt) and for Indian ore (vessels up to 35,000 dwt), and $5.23 to $6.25 per ton for Swaziland ore (vessels of 80,000 to 90,000 dwt).

FOREIGN TRADE

U.S. exports of iron ore increased by 31% compared with those of 1972 but the total remained well below the levels of 1951–71. Exports to Canada via Great Lakes ports accounted for 82% of the total.

U.S. imports of iron ore for consumption in 1973 increased by 21% compared with those of 1972 but the total was 1.6 million tons less than in 1970. The increase was due to strong demand at consuming plants throughout 1973. The principal countries of origin were Canada, which supplied 50% of the total quantity, Venezuela (30%), Brazil (7%), Liberia (6%), and Peru (3%). Imports from Brazil increased by 2 million tons compared with 1972 and were the highest on record. Of the total quantity imported, 63% was landed at U.S. ocean ports and 37% was landed at Great Lakes ports. Philadelphia, Baltimore, Cleveland, Chicago, Mobile, and Buffalo continued to be the principal ports of entry.

The average f.o.b. value of imported ore in 1973 was $12.32 per long ton, compared with $11.63 in 1972. The average value of ore exported was $13.80 per ton compared with $12.78 in the previous year.

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Angola.—Iron ore exports in 1973 by Cia. Mineira do Lobito (CML) totaled about 6.1 million tons, 23% more than in 1972. Of total shipments, 47% was destined for Japan, 25% for West Germany, and 14% for seven other countries.

CML, currently the only Angolan producer of iron ore, announced plans to build a pelletizing plant for ore from the Cassinga deposits. The plant will have a production capacity of 3 million tons of pellets per year and may be completed by 1977. Cost of the project was estimated at $87 million, of which 35% was to be provided by CML, 51% by two South African companies, and 14% by a group of British, West German, and French companies.

Cia. do Manganês de Angola, which formerly produced iron ore from deposits at Cassala, also announced plans to build a pelletizing plant and stated that the project would be managed by the Japanese firm of C. Itoh and Co. Exports of pellets were scheduled to start in 1976. The project includes construction of a pellet plant having production capacity of about 2 million tons per year, extension and improvement of the railway from Cassala to Luanda, and construction of loading facilities at the port of Luanda. Estimated total cost of the project was not announced.

Australia.—Production, shipments, and exports of iron ore set new records in 1973. Shipments totaled 86 million tons, of which about 72 million tons were exported. Exports to Japan totaled 65 million tons. Company shipments in 1972 and 1973, in thousand long tons, were as follows:

Producer	1972	1973
Hamersley Iron Pty. Ltd	22,117	27,268
Mt. Newman Mining Co. Pty. Ltd	21,443	26,316
Goldsworthy Mining Ltd	6,465	8,469
Broken Hill Pty. Co. Ltd	8,891	11,979
Cliffs Robe River Iron Associates	1,369	8,333
Savage River Mines	2,306	2,334
Frances Creek Iron Mining Corp	823	835
Western Mining Corp. Ltd	610	800
Total	64,024	86,334

Source: Skillings' Mining Review, various issues, 1973 and 1974.

Shipments of iron ore from the Paraburdoo mine were begun by Hamersley Iron Pty. Ltd. in 1973. Mt. Newman Mining Co.

[7] Metal Bulletin (London). Various issues, November–December 1973 and January 1974.

[8] The TEX Report Co. Ltd. (Tokyo). Iron Ore Import '73. Pages 96–146.

Pty. Ltd. and Goldsworthy Mining Ltd. also had expanded production capacity. Iron ore shipments from the Robe River project increased sharply as planned production facilities were completed early in the year. By yearend, total productive capacity of all Australian producers of iron ore was estimated at 115 million tons per year.

An estimated 9.15 million tons of iron ore pellets were shipped in 1973, compared with about 6 million tons in 1972. The Robe River project accounted for most of the increase. Hamersley was raising its productive capacity for pellets by 20%, to 3 million tons annually.

Kaiser Steel Corp. sold part of its interest in the Hamersley venture to a Japanese group in 1973. The sale reduced Kaiser's ownership share to 28.3%, from 34.5%. Hamersley was reported to have contracted to supply 3 million tons of iron ore during a period of 3 years to the People's Republic of China. Trial shipments to Chinese consumers were also reported by the Mt. Newman and Goldsworthy companies during 1973.

Bolivia.—Efforts were continued to utilize the iron deposits at Mutún. An agreement was signed in February 1973 to supply 50,000 tons of ore to the Argentine government for blast furnace tests at San Nicolás, Argentina. A second agreement, for 100,000 tons may be made if test results are favorable. Transportation facilities were limited, however, and only 15,000 tons of ore had been shipped to San Nicolás by yearend. The ore had to be hauled in 10-ton trucks about 75 miles from Mutún to a river loading point at Puerto Busch, from where it was carried by barge 1,250 miles to San Nicolás. For the river haul, a maximum draft of 9 feet was reportedly available for only about 4 months per year.

The possibility of constructing a direct-reduction plant near Mutún, to be fueled by natural gas from Bolivian fields, was being discussed with Brazilian authorities during negotiations for the sale of Bolivian gas to Brazil.

Brazil.—Production and exports of iron ore in 1973 were more than 30% greater than in previous years. Exports were estimated at 43 million tons, of which 24 million tons were destined for Europe and 14 million tons were destined for Japan.

Shipments of iron ore from the Aguas Claras mine of Mineraçoes Brasileiras Reunidas (MBR) began in July and the first export cargo (155,000 tons) was shipped from the Guaiba Island terminal late in November. The mine was expected to produce ore at the rate of about 11.3 million tons per year. At least 80% of planned production has already been sold under long term contracts with buyers in Europe, Japan, and Argentina. In 1973, MBR shipped 811,000 tons of ore from Aguas Claras and 1.4 million tons from other properties. The company was owned 51% by Empreendimentos Brasileiros de Mineração S.A. and 49% by St. John del Rey Mining Co. In the latter company, 66% of the ordinary shares was owned by the Hanna Mining Co.

Completion of the port facility at Guaiba Island, about 40 miles west of Rio de Janeiro, gave Brazil two iron ore ports capable of loading 250,000 dwt carriers. The other facility was operated by Companhia Vale do Rio Doce (CVRD) at Tubarão.

CVRD completed its second pelletizing plant at Tubarão early in 1973. The plant has a production capacity of 3 million tons of pellets per year and raised the total capacity of CVRD, the only producer of pellets, to 5 million tons annually. A third pellet plant, with production capacity of 3 million tons per year, was scheduled for completion at Tubarão by 1976. Sales of pellets reported by CVRD in 1973 totaled 4.4 million tons including 3.7 million tons for export. Sales in 1972 totaled about 2.5 million tons.

In Minas Gerais, the high-intensity wet magnetic separation plant being built by CVRD at the Caué mine was nearly completed by yearend. Twenty-six Jones-type separators have been installed at the plant, which was designed to produce 12 million tons of hematite concentrate per year from 20 million tons of crude ore. The plant is the first of its type to be built in the world.

In northern Brazil, feasibility studies for economic development of the Serra dos Carajas iron deposits were continued. Advanced engineering studies and related field work were expected to be completed in 1974. The deposits were reported to contain 1.87 billion tons of proved iron ore reserves averaging about 67% Fe. Amazônia Mineração S.A., the development company, was owned 51% by CVRD and 49% by a subsidiary of United States Steel Corp. The participating companies said that, depending on the results of these studies, initial shipments of ore could begin in 1978.

Canada.—Canadian production and exports of iron ore increased sharply in 1973 compared with the previous year. The greatly improved performance was largely due to the virtual absence of strikes, which had crippled production during the summer of 1972, but it was also due to strong demand for ore in foreign and domestic markets in 1973. Production set a new record, while exports, though 30% higher than in 1972, were less than in 1970. Production in 1973 totaled 48.9 million tons including 24.4 million tons of pellets. Exports totaled 37.9 million tons including 21.6 million tons to the United States, 11.8 million tons to the European Economic Community, and 3.8 million tons to Japan.

Two significant projects were completed by Iron Ore Co. of Canada late in 1973. Production capacity for concentrates at Labrador City was increased by 10 million tons per year, and production capacity for pellets was increased by 6 million tons with completion of a plant at Sept-Îles. Feed for the latter plant was flotation concentrates produced from Schefferville natural ores. With completion of these projects, Canadian production capacity for iron ore at yearend was 63.35 million tons per year, including 31 million tons of pellet capacity.

Quebec Cartier Mining Co. (QCM) continued construction of a major concentrating facility at Mt. Wright in northern Quebec. Initial production was scheduled to begin early in 1975. The project was designed to produce 16 million tons of concentrate per year. QCM was also developing deposits at Fire Lake, north of Gagnon, for production by 1976. Ore from the Fire Lake mine will be hauled on the Mt. Wright railways to the concentrator at Gagnon. The latter plant will continue to process ore from the Lac Jeannine deposits until 1976, when ore reserves at Lac Jeannine were expected to be exhausted.

The direct-reduction plant of Falconbridge Nickel Mines Ltd. at Sudbury was closed early in 1973 due to technical problems. The plant used the SL-RN process and had a production capacity of 300,000 tons of metallized pellets per year. Construction of a new SL-RN plant was begun in 1973 by the Steel Co. of Canada Ltd. The plant will process pellets produced at the Griffith mine and will have a production capacity of 400,000 tons of metallized product per year. At Contrecoeur, Quebec, a 400,000-ton-per-year direct reduction facility began regular production in May 1973. The plant employs the Midland-Ross process and was built for Siderurgie de Québec (Sidbec). Sidbec was using the product for feed to electric steel furnaces.

Iron ore shipments by the principal Canadian producers in 1973, in million long tons, were as follows:

Iron Ore Co. of Canada	20.5
Quebec Cartier Mining Co	9.0
Wabush Mines	5.4
Caland Ore Co. Ltd	2.1
Steep Rock Iron Mines Ltd	1.4
Griffith Mine	1.5
Algoma Steel Corp. Ltd	2.0
Adams Mine	1.2
National Steel Corp. of Canada Ltd. (Moose Mountain)	.7
Sherman Mine	1.0
Marmoraton Mining Co	.5

Chile.—Production and exports of iron ore in 1973 appeared to be about 9% and 15%, respectively, above 1972 levels. Exports in 1973 totaled 7,993,000 tons of which 95% was destined for Japan. Mine shipments by Compañía Acero del Pacífico S.A., the principal producer, totaled 9.28 million tons of which 35% originated at Romeral, 33% at Santa Barbara and Santa Fe, and 32% at Algorrobo. The company's shipments to Chile's iron and steel works at Huachipato totaled 919,000 tons.

China, People's Republic of.—Revised estimates of production of iron ore in China in 1971–73 (see table 20) are substantially greater than those previously published. This also applies to estimated production of pig iron (see table 14 in chapter on Iron and Steel). While the revised estimates may appear relatively high, and are considerably larger than those published elsewhere,[9] they are judged to be reasonably accurate by Bureau country specialists for China, considering the scarcity of information available.

European Economic Community (EEC).—Low-grade iron ore (25% to 32% Fe) continued to be produced by EEC countries in 1973 although it was significant mainly in France and Luxembourg. Domestic production continued to decline in West Germany, the United Kingdom, and Italy.

Imports of high-grade foreign ores by the EEC in 1973 were estimated to total 117 million tons. West Germany was the principal importer, with 46.2 million tons,

[9] Statistisches Bundesamt (Duesseldorf). Insert in Eisen und Stahl, 4. Vierteljahresheft 1973.

followed by the United Kingdom (22.8), Belgium-Luxembourg (17.8), Italy (estimated 13.5), France (9.8), and the Netherlands (6.9).

The major suppliers of iron ore to the EEC in 1973 were Sweden, with 27.2 million tons, followed by Brazil (19.8), Liberia (14.4), and Canada (11.2).

In the United Kingdom, the British Steel Corp. (BSC) contracted with a subsidiary of Allis-Chalmers Corp. for construction of a pelletizing plant at the Redcar steelworks. The plant will have a production capacity of 3 million tons of pellets per year and was scheduled for completion in 1975. The only large pelletizing plant known to be operating in the EEC in 1973 was at the Hoogovens-Hoesch steelworks in the Netherlands. This facility had a production capacity of about 3.5 million tons of pellets per year and was fed by imported ores. Other pelletizing plants were located at Hamburg, West Germany, where a direct-reduction plant of the Midland-Ross type was operated by Korf Industrie und Handel G.m.b. H., and at Scarlino, Italy, where iron oxide residues from pyrite were pelletized by Montedison S.p.A.

The Redcar iron ore terminal at Teesside was also completed by BSC in 1973 and the first 100,000-ton cargo of pellets was received in September. Completion of the Redcar terminal gave Britain two iron-ore ports capable of accommodating 100,000-dwt vessels. The other facility was located at Port Talbot. BSC also planned another deep-water terminal in Scotland. The company's terminal at Immingham, completed in 1972, may eventually accommodate 100,000-ton vessels.

Finland.—An agreement was signed October 31, 1973, by the Governments of Finland and the Soviet Union concerning development of the Kostomus iron deposits in Soviet Karelia. The project was planned to eventually produce about 8 million tons of iron ore pellets per year, with production beginning in 1978 at the rate of 2.7 million tons per year. Construction of the facilities will be done mostly by Finnish companies, with the Soviet Union supplying most of the machinery. Part of the ore produced would be consumed in Finland, and part would be exported from Finnish ports.

Finland's annual requirements for iron ore were expected to increase to more than 2 million tons by 1980. Domestic mines were not expected to supply more than one third of this total. Construction of a second blast furnace, with a production capacity of about 600,000 tons of pig iron per year, was started at Raahe in 1973. Completion was scheduled by 1976. The Raajärvi mine, which currently accounts for most of the iron ore mined in Finland, was expected to be depleted in 1975. Its production will be replaced by output from the Rautuvaara underground mine, now under construction near Kolari. Imports of iron ore by Finland in 1973 totaled 948,000 tons, 23% more than in 1972.

India.—Exports of iron ore in 1973 totaled about 23.2 million tons, of which 83% was shipped to Japan. This included about 400,000 tons of pellets from the plant of Chowgule & Co. Ltd. in Goa. Domestic consumption of iron ore was approximately 11 million tons, an increase of 2.8% compared with 1972.

Indian production of pellets was estimated at 1.5 million tons in 1973. Two-thirds of the output were produced by Tata Iron & Steel Co. Ltd. at Naomundi, where a plant was reportedly completed late in 1972. Chowgule & Co. planned to increase pellet production capacity in Goa by about 1.2 million tons per year, but no construction contracts were announced by yearend.

Iran.—Under a project announced in 1973, production of prereduced iron ore was scheduled to begin at Ahvaz in mid-1975. Three reduction plants of the Midland-Ross type, each with a production capacity of 400,000 tons of prereduced iron ore or pellets per year, were scheduled to be built. Design and construction of the plants will be supervised by Korf Engineering G.m.b.H. of West Germany, under license from the Midland-Ross Corp. Construction of additional direct-reduction plants, not necessarily of the Midrex type, was being considered at Ahvaz, Bandar Abbas, Mashhad, and Isfahan.

Iron ore to supply the reduction plants at Ahvaz was expected to be imported. Iranian authorities were reportedly considering investment of $300 million for development of iron deposits and port facilities in the Indian state of Mysore.

Iron ore for the Iranian steelworks at Isfahan was being supplied from deposits at Bafq. The feasibility of developing additional deposits, south of Kerman, was being investigated by the Swedish firm of Gränges AB.

Japan.—Imports of iron ore by Japan

in 1973 totaled nearly 133 million tons, 21% more than in 1972. Australia was the major supplying country, accounting for 49% of the total, followed by India (14%) and Brazil (9%). The remaining 28% was supplied by Chile, Peru, and 19 other countries.

Production of pellets, mostly from imported ore, was 6.2 million tons in 1973, an increase of nearly 2.4 million tons compared with 1972. The increase appeared to be due to production at Hirohata, where a new pelletizing facility was completed in January. Imports of pellets were estimated at 11 million tons.

Consumption of iron ore, excluding manganiferous ores, was approximately 128 million tons including about 900,000 tons of iron ore produced in Japan and an estimated 17 million tons of pellets from all sources.

Liberia.—Exports of iron ore from Liberia in 1973 totaled nearly 25 million tons, an increase of 11% compared with 1972. Of the total quantity, 76% was shipped to EEC countries, 11% to the United States, 10% to Japan, and the remainder to Spain and Romania. Three of the four producing companies increased production and exports in 1973. A decline was registered by National Iron Ore Co. due to startup problems at its new concentrator. Shipments of iron ore, by company, in thousand tons, were as follows:

Liberian-American Swedish Minerals Co. (LAMCO)	[1] 12,584
Bong Mining Co	[2] 6,792
National Iron Ore Co	[e] 3,300
Liberia Mining Co	[e] 2,300
Total	24,976

[e] Author's estimate.
[1] Including 1,685,000 tons of pellets.
[2] Including 2,274,000 tons of pellets.

Sources: U.S. Embassy, Monrovia, Liberia. State Department Airgram A–18, Mar. 5, 1974, and Skillings' Mining Review, various issues, 1974.

Mexico.—Cia. Fundidora de Fierro y Acero de Monterrey, S.A. contracted with the Allis-Chalmers Co. of Milwaukee, Wis., for construction of an iron ore pelletizing plant at Monterrey. Production capacity of the plant will be about 1.5 million tons of self-fluxing pellets per year. Completion was planned for 1976. Fundidora shipped 1.3 million tons of iron ore to Monterrey in 1973 from its four mines in Durango, Coahuila, Oaxaca, and Colima.

Construction of a 600,000-ton-per-year pelletizing plant was underway at the La Perla mine in Chihuahua. Completion of the plant was expected early in 1974. Output of iron ore at La Perla in 1973 was 2.55 million tons, with about 2 million tons shipped to the steelworks of Altos Hornos de Mexico S.A. at Monclova.

Siderúrgica Lázaro Cardenas-Las Truchas, S.A. (SICARTSA) ordered a pelletizing plant from Lürgi Chemie und Hüttentechnik G.m.b.H. in 1973. The plant will be built near Lázaro Cardenas on the Michoacan coast and will have a production capacity of 2 million tons of self-fluxing pellets per year. Iron ore fed to the plant will be magnetite concentrate, delivered in slurry form through a 9-mile pipeline. A date for completion was not announced.

The pelletizing plants described above are in addition to the 1.5-million-ton plant under construction at Manzanillo by Consorcio Minero Peña Colorada S.A.

Shipments of iron ore pellets by Las Encinas S.A. from its mine and plant near Alzada, Colima, totaled about 1.15 million tons in 1973.

Norway.—The second iron ore pelletizing line of A/S Sydvaranger at Kirkenes was scheduled to begin production by mid-1974. The company's production capacity for pellets will then be 2.4 million tons per year.

Increased requirements for rock stripping and crude ore production at the Sydvaranger and Rana operations led to purchases of large mining equipment in 1973. Five 150-ton trucks were scheduled for delivery to A/S Sydvaranger in 1974. A/S Norsk Jernverk purchased three 150-ton trucks and an electric shovel with 15-cubic-yard bucket for the Rana mine.

Panama.—Shipments of iron concentrates to Japan, halted in mid-1972 owing to berth trouble at Isla Bona, were expected to resume in the spring of 1974. The concentrates are produced from Pacific beach sands in the Balboa district by Hierro Panama, S.A. The scheduled rate of shipments was 300,000 tons per year.

Peru.—Shipments of iron ore products in 1973 by Marcona Mining Co. totaled 9.4 million tons, an increase of 3.6% compared with 1972. Exports totaled 9.0 million tons, of which 65% was destined for Japan, 18% for the United States, and 17% for countries of the EEC. Exports included 3.8 million tons of iron ore pellets and 1.2 million tons of slurry and filter cake.

Negotiations between the Marcona Co. and

Japanese interests for expanding production capacity of pelletizing facilities at San Nicolas were continued in 1973. Production capacity was expected to be increased to 7.5 million tons per year by 1976 at a cost of about $72 million. The project was being reviewed by the Peruvian Government.

Saudi Arabia.—The Marcona Corp. concluded an arrangement with Petromin, a Saudi Arabian Government company, for a joint study of the feasibility of establishing a steelmaking plant on the Arabian Gulf coast. The proposed plant would include facilities for receiving slurried iron ore concentrate, as well as for pelletizing and direct-reduction of the ore using natural gas. Other companies involved in the study are Gilmore Steel Corp. of San Francisco and Midland-Ross Corp. of Cleveland.

South Africa, Republic of.—Although iron ore export contracts necessary to support the Sishen-Saldanha Bay export project were not yet negotiated, the Government approved the project in April and construction of the 530-mile railroad reportedly began in 1973. The project was designed for export of 15 million tons of iron ore per year. At Sishen, a new open pit mine was being developed to raise production capacity to 9 million tons annually.

Production of iron ore declined slightly in 1973 compared with that of 1972, but exports increased 28% to 6.3 million tons. Sales of ore to domestic consumers totaled about 6.6 million tons, slightly less than in 1972.

Sweden.—Production of iron ore in 1973 increased 5% compared with that of 1972, but exports increased by nearly 20% to 32.4 million tons as Swedish producers drew heavily on stockpiles. Total shipments of iron ore and pellets to domestic and foreign markets by the principal producers in 1973, in thousand long tons, were as follows:

	Pellets	Other	Total
Luossavaara-Kiirunavaara AB (LKAB)	5,926	23,219	29,145
Gränges AB	1,191	2,586	3,777
Stora Kopparbergs Bergslags AB	--	861	861
Total	7,117	26,666	33,783

At the Malmberget operations of LKAB, production capacity of the concentrator was increased to 8 million tons per year, and capacity of the pelletizing plant was increased to 4 million tons per year. At Grängesberg, Gränges AB planned to invest about $9 million to raise production capacity for low-phosphorus concentrates to 2.5 million tons per year.

Tunisia.—The Tunisian Government signed a letter of intent in 1973 concerning plans to construct a direct-reduction iron ore plant at Gabes. The proposed plant, believed to be of the Midland-Ross type, would have an initial production capacity of 1 million tons of metallized ore per year. Iron ore for the project would be imported from Brazil. A completion date for the project was not announced. The companies involved were Korf Industrie und Handel G.m.b.H., C. Itoh and Co. Ltd., and CVRD.

Production of iron ore continued to decline in 1973 due to depletion of reserves at the Djerissa and Tamera mines. Exports reportedly declined 30% to 383,000 tons owing to increased requirements for ore at the El Fouladh steel plant.

U.S.S.R.—Exports of iron ore from the Soviet Union in 1973 totaled approximately 40.7 million tons, of which about 10% was shipped to Japan and West Europe.

The Soviet firm V/O Metallurgimport awarded a contract in 1973 to Allis-Chalmers Co. for construction of a two-line pelletizing facility for iron ore near Kremchug in the Ukraine. The plant will have a production capacity of 6 million tons of pellets per year. Production of pellets was scheduled to start in 1977. An agreement was also made with Finnish authorities for construction of pellet plants in Karelia (see Finland).

Soviet production of pellets in 1973 was reported to be about 21 million tons. This was equivalent to about 10% of the reported output of usable iron ore. Pellet production in 1971 and 1972 was 13.25 and 17.2 million long tons, respectively.

Negotiations between Korf Industrie und Handel G.m.b.H. and Soviet authorities, concerning establishment of a large direct-reduction facility, were reported in 1973 but no contracts were announced by year-end.

Venezuela.—Production and exports of iron ore increased about 20% in 1973, compared with those of 1972. Shipments by Orinoco Mining Co. and Iron Mines Co. of Venezuela totaled 21.4 million tons, of which about 21.1 million tons was exported and the remainder was destined for consumption in Venezuela. Of the quantity exported, approximately 63% was sent to the United States and 37% was shipped to

European consumers. Data on production or shipments of iron ore in 1973 by the State-owned Siderúrgica del Orinoco S.A. were not available.

Expansion of production facilities by Orinoco Mining Co. was nearly completed in 1973. The company's production capacity for iron ore will be 25 million tons per year early in 1974. Output capacity of Iron Mines Co. of Venezuela was believed to be 4 million tons per year.

Output of prereduced iron ore briquets at Puerto Ordaz was less than expected in 1973, owing to temporary technical difficulties. Production amounted to about 122,000 tons, of which 9,300 tons was shipped to the United States and the remainder was shipped to Venezuelan consumers.

A project to build a direct-reduction plant in the Guayana region was announced in 1973. The plant will employ the Fior process developed by Exxon Research & Engineering Co. and will have a production capacity of 400,000 tons of briquetted, prereduced ore per year. Completion was planned by mid-1975. Arthur G. McKee & Co. was in charge of construction. Participants in the venture included Lukens Steel Co. of Coatesville, Pa., and two Venezuelan companies.

TECHNOLOGY

Trends toward increasing size and productive capacity of iron ore mining, processing, and handling equipment, previously noted in this and other publications[10] of the Bureau of Mines, continued in 1973.

Large rotary drills with bits 12 to 15 inches in diameter were already in use or planned for blast-hole drilling at most taconite operations in the Lake Superior district in 1973. The models used were either the Gardner-Denver GD–120 or Bucyrus-Erie 61–R. These drills will also be used at the Hibbing and Tilden taconite projects. Jet-piercing drills continued to be used at several locations for all production drilling or in conjunction with rotary units.

A medium-size rotary drill (GD–80), using a table-drive instead of conventional top-drive mechanism, was tested for 3 months in 1973 at the McKinley natural-ore mine by Jones & Laughlin Steel Corp. The drill was said to have several advantages over top-driven machines including greater down-pressure and penetration rate, less vibration and stem-wear, and lower maintenance costs.

The number of autogenous grinding mills used in taconite processing was also increasing. Autogenous grinding will be used at the Hibbing and Tilden concentrators scheduled to start operating in 1976 and 1974, respectively. The method is currently used at the National, Butler, and Empire operations. Two new mills were installed in 1973 at the Empire concentrator where production capacity was being increased by 50%.

High-intensity magnetic separation continued to be a subject of wide interest because of its potential use in beneficiating low-grade hematite materials such as oxidized taconite. A new type of separator, using a continuous-flow process capable of processing large volumes of material, was developed at the Massachusetts Institute of Technology.[11] Known as the "Carousel" separator, the device uses stainless steel wool as the collector of ferromagnetic particles. This was said to increase the working volume of the magnetic field compared with machines previously built. The separator was scheduled to be tested on the Mesabi range in 1974 at the Hibbing laboratory of Hanna Mining Co. A method of high-intensity separation was also being investigated at the University of Wisconsin in 1973, under a grant by the National Science Foundation. The latter tests would be made on iron-bearing materials from the Black River Falls area of Wisconsin. The application of pulsed magnetic fields to matrix-type separators was described in a Bureau of Mines publication.[12]

In Brazil, the first commercial-scale beneficiation plant using high-intensity wet magnetic separation was nearing comple-

[10] U.S. Bureau of Mines, Technologic Trends in the Mineral Industry, 1971. IC 8581, 1973, 61 pp.

———. Technologic and Related Trends in the Mineral Industries, 1972. IC 8603, 1973, 43 pp.

———. Technologic and Related Trends in the Mineral Industries, 1973. IC 8643, 1974, 52 pp.

[11] Oberteuffer, J. A., and D. R. Kelland. eds. Proc. of the High-Gradient Magnetic Separation Symposium. Massachusetts Institute of Technology, May 22, 1973, 116 pp.

Gaudin, A. M. Progress in Magnetic Separation Using High-Intensity, High-Gradient Separators. Paper pres. at Am. Min. Congress, Denver, Colo., Sept. 9–12, 1973.

[12] Fraas, Foster. Alternating Current Matrix Type Magnetic Separator. RI 7746, 1973, 13 pp.

tion. Most of the 26 Jones-type separators scheduled to be installed were already oprating in 1973. The plant was designed to process 20 million tons of medium-grade hematite ore per year. The plant is located at the Caué mine near Belo Horizonte and is owned by CVRD.

Laboratory research was reported on recovery of specular hematite from spiral tailings in which a Lamflo sluice was used in conjunction with high-intensity magnetic separation or flotation equipment.[13] It was estimated that about 60% of the iron units presently lost in such tailings can be recovered at a grade of about 66% Fe by a variety of methods, although more data are needed to estimate costs of such recovery. It was also stated that high-intensity magnetic separation is now competitive with froth flotation due to pollution control regulations.

Demand for iron ore pellets at iron and steelmaking centers continued to grow. New pelletizing plants comprising about 45 million tons of annual production capacity were completed, under construction, or announced as new projects in the United States and 11 other countries during 1973. Pelletizing of furnace dust and mill scale was being investigated by some U.S. and foreign steel companies as well as by the Bureau of Mines. The Swedish "Grängcold" cold-bonding pelletizing process was being applied to agglomeration of steel mill wastes.[14]

Direct reduction of iron ore also increased. Armco Steel Corp. began full production at its Houston, Tex. plant in 1973. The plant has a production capacity of about 1,000 tons of metallized ore per day. In Venezuela, all units of United States Steel Corp.'s large reduction facility at Puerto Ordaz were operated during the year although production of briquets was restricted by temporary problems. In Canada, regular production of metallized pellets was begun in May at the Contrecoeur plant of Sidbec. The plant uses the Midrex process and has a production capacity of 400,000 tons of metallized pellets per year. In Iran, a project to build three 400,000-ton-per-year Midrex plants was begun at Ahvāz. A 1-million-ton facility was planned in Tunisia, and another was proposed for Saudi Arabia.

A comprehensive survey of the iron industry of the United States and the world was published by the Bureau of Mines.[15] The survey includes a section on technology of iron ore mining and beneficiation, including pelletizing and direct-reduction processes.

The Bureau of Mines continued research on beneficiation of nonmagnetic taconite and on methods of production and metallization of iron ore pellets. The processes of selective flocculation-desliming-flotation and reduction roasting-magnetic separation-flotation were being tested on hematitic and goethitic taconite from the western Mesabi range. The use of western lignite and subbituminous coal as reductants for taconite roasting or as fuel for induration of pellets, was being studied as a possible alternative to natural gas and fuel oil. Research was also being conducted on solid-liquid separation processes for reclamation of process water; the use of plastic refuse materials as binders for agglomerating fine materials such as iron and steel plant dusts and for coating metallized pellets; and utilization of magnetic fluids for beneficiation of ores. Publications issued during the year described the effects of thermal treatment on concentratability of oxidized taconite from the western Mesabi;[16] anionic flotation of nonmagnetic taconite from the Marquette range and some advantages of autogenous grinding;[17] the production of iron oxide superconcentrates by caustic leaching;[18] and attempts to reduce the phosphorus content of Alabama hematite ore.[19] Two publications on materials handling research, including a study of bucket-wheel excavators, were also released.[20]

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[13] Lawver, J. E., and W. P. Dyrenforth. New Methods of Scavenging Iron Units. Min. Congress J. v. 59, No. 4, April 1973, pp. 46–48.

[14] George, H. D., and E. B. Boardman. The IMS-Grangcold Process for Agglomerating Steel Mill Waste Materials. Granges Ore News, August 1973, pp. 13–21.

[15] Reno, H. T., and F. E. Brantley. Iron: A Materials Survey. IC 8574, 1973, 117 pp.

[16] Drost, J. J., and W. M. Mahan. Effects of Thermal Treatment Upon Concentratability of a Nonmagnetic Taconite Iron Ore. RI 7797, 1973, 15 pp.

[17] Frommer, D. W., P. A. Wasson, and D. L. Veith. Flotation of Marquette Range Nonmagnetic Taconite Using Innovative Procedures. RI 7826, 1973, 30 pp.

[18] Green, R. E., and A. F. Colombo. Iron Oxide Superconcentrates by Caustic Leaching. RI 7812, 1973, 11 pp.

[19] Lamont, W. E., T. N. McVay, C. E. Spruiell, Jr., and I. L. Feld. Phosphorus Removal From Birmingham, Ala., Calcareous Iron Ores. RI 7728, 1973, 15 pp.

[20] Wancheck, G. A., and R. S. Fowkes. Materials Handling Research: Shear Properties of Several Granular Materials. RI 7731, 1973, 36 pp.

Price, G. C., C. B. Manula, and Rajaraman Venkataramani. Materials Handling Research: The Bucket-Wheel Excavator. IC 8580, 1973, 79 pp.

In the iron ore industry, as in other industries, much money and manpower were being directed toward design and installation of adequate methods and equipment to meet increasingly stringent environmental control regulations. This was generating new technology in the fields of dust control and reclamation of water and land. Methods of stabilizing and vegetating tailings were being developed, and wholly closed or nearly closed systems were being designed for water supplies to taconite concentrators. Methods of dust control at iron ore shipping and receiving terminals included a fogging system for ship-unloading at Europoort, the Netherlands and telescoping chutes for shiploading at Palua, Venezuela.[21] There was also a need for better measuring techniques and equipment and coordination of standards for air and water quality.

[21] Yu, A. T. The Battle Against Dockside Dust. Skillings' Mining Review, v. 62, No. 7, Feb. 17, 1973, pp. 8–24.

Table 2.—Crude iron ore mined in the United States, by district, State, and variety

(Thousand long tons and exclusive of ore containing 5% or more manganese)

District and State	1972					1973				
	Number of mines	Hematite	Limonite	Magnetite	Total quantity [1]	Number of mines	Hematite	Limonite	Magnetite	Total quantity [1]
Lake Superior:										
Michigan	5	W	--	W	26,919	5	W	--	W	25,917
Minnesota	18	23,053	--	103,046	126,099	27	31,154	--	124,031	155,185
Wisconsin	1	--	--	2,477	2,477	1	--	--	2,681	2,681
Total reportable	24	23,053	--	105,523	155,495	33	31,154	--	126,712	183,783
Southeastern States:										
Alabama	3	--	909	--	909	2	--	W	--	([2])
Georgia and North Carolina	3	--	W	W	371	3	--	W	W	[3] 728
Total reportable	6	--	909	--	1,280	5	--	W	W	728
Northeastern States: New York and Pennsylvania	4	--	--	6,818	6,818	4	--	--	7,248	7,248
Western States:										
Missouri	2	--	--	4,703	4,703	2	--	--	4,480	4,480
Montana	1	--	--	9	9	1	--	--	13	13
Nevada	--	--	--	--	([4])	3	W	--	W	119
Utah	4	W	--	W	4,828	4	W	--	W	3,788
Wyoming	3	W	--	W	4,836	3	W	--	W	4,827
Other [5]	14	W	W	W	9,678	11	W	W	W	13,672
Total reportable [1]	24	--	--	4,712	24,054	24	--	--	4,493	26,898
Total withheld	--	12,045	3,948	30,639	([6])	--	11,802	3,866	33,382	([6])
Grand total [1]	58	35,097	4,858	147,693	187,648	66	42,956	3,866	171,835	218,658

W Withheld to avoid disclosing individual company confidential data; included with "Total withheld" and "Total quantity."
[1] Data may not add to totals shown because of independent rounding.
[2] Included with Georgia and North Carolina.
[3] Includes Alabama in 1973.
[4] Included with "Other" in 1972.
[5] Includes Arizona, Arkansas, California, Colorado, Idaho, Nevada (in 1972), New Mexico, and Texas.
[6] Total withheld data included with "Total quantity" for each respective district or State.

Table 3.—Crude iron ore mined in the United States by district, State, and mining method

(Thousand long tons and exclusive of ore containing 5% or more manganese)

District and State	1972 Open pit	1972 Underground	1972 Total quantity [1]	1973 Open pit	1973 Underground	1973 Total quantity [1]
Lake Superior:						
Michigan	24,231	2,688	26,919	23,552	2,365	25,917
Minnesota	126,099	--	126,099	155,185	--	155,185
Wisconsin	2,477	--	2,477	2,681	--	2,681
Total reportable [1]	152,807	2,688	155,495	181,418	2,365	183,783
Southeastern States:						
Alabama	909	--	909	(2)	--	(2)
Georgia and North Carolina	371	--	371	[3] 728	--	[3] 728
Total reportable	1,280	--	1,280	728	--	728
Northeastern States: New York and Pennsylvania	W	W	6,818	W	W	7,248
Western States:						
Missouri	--	4,703	4,703	--	4,480	4,480
Montana	9	--	9	13	--	13
Nevada	--	--	(4)	119	--	119
Utah	4,828	--	4,828	3,788	--	3,788
Wyoming	W	W	4,836	W	W	4,827
Other [5]	W	W	9,678	13,672	--	13,672
Total reportable [1]	4,837	4,703	24,054	17,592	4,480	26,889
Total withheld	18,157	3,175	(6)	9,255	2,820	(6)
Grand total [1]	177,082	10,566	187,648	208,992	9,665	218,658

W Withheld to avoid disclosing individual company confidential data; included with "Total withheld" and "Total quantity."
[1] Data may not add to totals shown because of independent rounding.
[2] Included with Georgia and North Carolina.
[3] Includes Alabama in 1973.
[4] Included with "Other" in 1972.
[5] Includes Arizona, Arkansas, California, Colorado, Idaho, Nevada (1972), New Mexico, and Texas.
[6] Total withheld data included with "Total quantity" for each respective district or State.

Table 4.—Crude iron ore shipped from mines in the United States, by district, State, and disposition

(Thousand long tons and exclusive of ore containing 5% or more manganese)

District and State	1972 Direct to consumers	1972 To beneficiating plants	1972 Total quantity [1]	1973 Direct to consumers	1973 To beneficiating plants	1973 Total quantity [1]
Lake Superior:						
Michigan	4,271	148,954	27,058	1,954	179,403	26,052
Minnesota			126,166			155,305
Wisconsin	--	2,477	2,477	--	2,681	2,681
Total reportable	4,271	151,431	155,702	1,954	182,084	184,038
Southeastern States:						
Alabama	--	909	909	--	(2)	(2)
Georgia and North Carolina	--	371	371	--	[3] 659	[3] 659
Total reportable	--	1,280	1,280	--	659	659
Northeastern States: New York and Pennsylvania	--	6,702	6,702	--	7,381	7,381
Western States:						
Missouri	--	4,726	4,726	--	4,483	4,483
Montana	9	--	9	13	--	13
Nevada	--	--	(4)	119	--	119
Utah	W	W	4,869	W	W	3,805
Wyoming	W	W	4,836	W	W	4,827
Other [5]	283	9,697	9,980	228	13,487	13,714
Total reportable [1]	291	14,423	24,420	360	17,970	26,961
Total withheld	1,311	8,394	(6)	1,447	7,186	(6)
Grand total [1]	5,873	182,230	188,103	3,760	215,280	219,040

W Withheld to avoid disclosing individual company confidential data; included with "Total withheld" and "Total quantity."
[1] Data may not add to totals shown because of independent rounding.
[2] Included with Georgia and North Carolina.
[3] Includes Alabama in 1973.
[4] Included with "Other" in 1972.
[5] Includes Arizona, Arkansas, California, Colorado, Idaho, Nevada (1972), New Mexico, and Texas.
[6] Total withheld data included with "Total quantity" for each respective district or State.

Table 5.—Usable iron ore produced in the United States, by district, State, and variety

(Thousand long tons and exclusive of ore containing 5% or more manganese)

District and State	1972 Hematite	1972 Limonite	1972 Magnetite	1972 Total quantity[1]	1973 Hematite	1973 Limonite	1973 Magnetite	1973 Total quantity[1]
Lake Superior:								
Michigan	W	--	W	11,664	W	--	W	11,440
Minnesota	14,452	--	34,546	48,998	21,235	--	38,786	60,021
Wisconsin	--	--	888	888	--	--	956	956
Total reportable[1]	14,452	--	35,434	61,550	21,235	--	39,742	72,416
Southeastern States:								
Alabama	--	311	--	311	--	W	--	([2])
Georgia and North Carolina	--	W	W	122	--	W	W	[3] 317
Total reportable	--	311	--	433	--	W	W	317
Northeastern States: New York and Pennsylvania	--	--	2,612	2,612	--	--	2,608	2,608
Western States:								
Missouri	--	--	2,684	2,684	--	--	2,625	2,625
Montana	--	--	9	9	--	--	13	13
Nevada	--	--	--	([4])	W	--	W	119
Utah	W	--	W	1,872	W	--	W	2,044
Wyoming	W	--	W	2,030	W	--	W	2,070
Other[5]	W	W	3,056	3,933	W	W	4,406	5,164
Total reportable[1]	--	--	5,749	10,529	--	--	7,044	12,035
Total withheld	7,143	873	8,549	([6])	6,989	1,603	8,695	([6])
Total all States[1]	21,595	1,184	52,344	75,124	28,224	1,063	58,089	87,376
Byproduct ore[7]	--	--	--	310	--	--	--	293
Grand total[1]	21,595	1,184	52,344	75,434	28,224	1,063	58,089	87,669

W Withheld to avoid disclosing individual company confidential data; included with "Total withheld" and "Total quantity."

[1] Data may not add to totals shown because of independent rounding.

[2] Included with Georgia and North Carolina.

[3] Includes Alabama in 1973.

[4] Included with "Other" in 1972.

[5] Includes Arizona, Arkansas, California, Colorado, Idaho, Nevada (1972), New Mexico, and Texas.

[6] Total withheld data included with "Total quantity" for each respective district or State.

[7] Mostly cinder and sinter obtained from treating pyrites. Ore was treated in New Mexico, Tennessee, and Virginia.

Table 6.—Usable iron ore produced in the United States, by district, State and type of product

(Thousand long tons and exclusive of ore containing 5% or more manganese)

District and State	1972 Direct shipping ore	1972 Agglomerates	1972 Concentrates	1972 Iron content (natural percent)	1973 Direct shipping ore	1973 Agglomerates	1973 Concentrates	1973 Iron content (natural percent)
Lake Superior:								
Michigan	4,088	10,717	11,311	63	1,930	10,750	17,179	63
Minnesota		34,546		60		41,601		61
Wisconsin	--	888	--	65	--	956	--	65
Total reportable	4,088	46,151	11,311	61	1,930	53,307	17,179	61
Southeastern States:								
Alabama	--	--	311	47	--	--	(1)	44
Georgia and North Carolina	--	--	122	50	--	--	[2] 317	46
Total reportable	--	--	433	48	--	--	317	46
Northeastern States: New York and Pennsylvania	--	W	W	64	--	W	W	64
Western States:								
Missouri	--	2,661	23	65	--	2,595	30	65
Montana	9	--	--	45	13	--	--	35
Nevada	--	--	--	(3)	119	--	--	62
Utah	W	--	W	55	W	--	W	55
Wyoming	W	W	W	60	W	W	W	61
Other [4]	408	W	W	60	227	W	W	60
Total reportable	417	2,661	23	61	359	2,595	30	60
Total withheld	1,326	5,808	2,907	60	1,447	6,370	3,842	62
Total all States [5]	5,830	54,620	14,674	61	3,737	62,271	21,368	61
Byproduct ore [6]	--	227	83	63	--	90	203	61
Grand total [5]	5,830	54,847	14,757	61	3,737	62,361	21,571	61

W Withheld to avoid disclosing individual company confidential data; included with "Total withheld."
[1] Included with Georgia and North Carolina.
[2] Includes Alabama in 1973.
[3] Included with "Other" in 1972.
[4] Includes Arizona, Arkansas, California, Colorado, Idaho, Nevada (1972), New Mexico, and Texas.
[5] Data may not add to totals shown because of independent rounding.
[6] Mostly cinder and sinter obtained from treating pyrites.

Table 7.—Shipments of usable iron ore from mines in the United States in 1973

(Thousand long tons and thousand dollars; exclusive of ore containing 5% or more manganese)

District and State	Gross weight of ore shipped				Iron content of ore shipped				Total value [1]
	Direct shipping ore	Agglomerates	Concentrates	Total quantity [1]	Direct shipping ore	Agglomerates	Concentrates	Total quantity [1]	
Lake Superior:									
Michigan	1,954 (Michigan and Minnesota combined)	11,293	18,155 (Michigan and Minnesota combined)	12,389	1,024 (Michigan and Minnesota combined)	7,075	9,923 (Michigan and Minnesota combined)	7,665	180,194
Minnesota		43,601		62,614		27,320		37,677	782,197
Wisconsin	--	956	--	956	--	620	--	620	W
Total reportable	1,954	55,850	18,155	75,959	1,024	35,015	9,923	45,962	962,391
Southeastern States:									
Alabama	--	--	271	271	--	--	121	121	1,408
Georgia and North Carolina	--	--	105	105	--	--	53	53	765
Total reportable	--	--	376	376	--	--	174	174	2,173
Northeastern States: New York and Pennsylvania	--	W	W	2,388	--	W	W	1,536	40,528
Western States:									
Missouri	--	2,600	30	2,630	--	1,686	21	1,706	W
Montana	13	--	--	13	5	--	--	5	W
Nevada	119	--	--	119	74	--	--	74	W
Utah	1,441	--	545	1,986	803	--	300	1,103	13,581
Wyoming	6	W	W	2,070	2	W	W	1,254	25,568
Other [2]	227	W	W	5,114	146	W	W	3,045	64,468
Total reportable	1,806	2,600	575	11,932	1,030	1,686	321	7,187	103,617
Total withheld	--	6,404	2,934	(3)	--	4,024	1,664	(3)	55,001
Total all States	3,760	64,853	22,041	90,654	2,054	40,725	12,082	54,860	1,163,710
Byproduct ore [4]	--	209	--	209	--	133	--	133	2,591
Grand total [1]	3,760	65,062	22,041	90,863	2,054	40,858	12,082	54,993	1,166,300

W Withheld to avoid disclosing individual company confidential data; included with "Total withheld" and "Total quantity."

[1] Data may not add to totals shown because of independent rounding.

[2] Includes Arizona, Arkansas, California, Colorida, Idaho, New Mexico, and Texas.

[3] Total withheld data included with "Total quantity" for each respective district or State.

[4] Mostly cinder and sinter obtained from treating pyrites. Ore treated in Tennessee and Virgina.

Table 8.—Usable iron ore produced in Lake Superior district, by range

(Thousand long tons and exclusive after 1905 of ore containing 5% or more manganese)

Year	Marquette	Menominee	Gogebic	Vermilion	Mesabi	Cuyuna	Spring Valley	Black River Falls	Total [1]
1854–1968	369,687	300,275	320,334	103,528	2,665,178	70,336	8,149	--	3,837,485
1969	10,048	3,369	--	--	55,275	--	--	38	68,730
1970	10,363	2,394	--	--	56,073	--	--	806	69,636
1971	9,495	2,424	--	--	51,283	--	--	832	64,034
1972	9,131	2,533	--	--	48,998	--	--	888	61,550
1973	9,036	2,404	--	--	60,021	--	--	956	72,416
Total	417,760	313,399	320,334	103,528	2,936,828	70,336	8,149	3,520	4,173,851

[1] Data may not add to totals shown because of independent rounding.

Table 9.—Average analyses of total tonnage [1] of all grades of iron ore shipped from the U.S. Lake Superior district

Year	Quantity (thousand long tons)	Content percent [2]					
		Iron	Phosphorus	Silica	Manganese	Alumina	Moisture
1969	71,389	59.04	0.045	7.32	0.45	0.69	4.82
1970	69,072	59.36	.041	7.40	.39	.72	4.62
1971	61,776	60.06	.039	7.08	.33	.59	r 4.09
1972	64,721	60.40	.031	6.76	.30	.52	3.93
1973	76,281	60.66	.030	6.77	.33	.41	3.79

r Revised.

[1] Railroad weight-gross tons.

[2] Iron and moisture on natural basis; phosphorus, silica, manganese, and alumina on dried basis.

Source: American Iron Ore Association. Iron Ore, 1973, p. 92.

Table 10.—Consumption of iron ore and agglomerates in the United States in 1973

(Thousand long tons and exclusive of ore containing 5% or more manganese)

State	Iron ore and concentrates [1]		Agglomerates [2]		Miscellaneous [3]	Total reportable
	Blast furnaces	Steel furnaces	Blast furnaces	Steel furnaces		
Alabama, Kentucky, Texas	2,807	W	7,786	W	NA	10,593
California, Colorado, Utah	4,914	W	6,660	W	NA	11,574
Ohio and West Virginia	5,518	W	23,847	W	NA	29,365
Illinois and Indiana	2,697	W	32,440	W	NA	35,137
Michigan and Minnesota	435	W	10,697	W	NA	11,132
Maryland, New York, Pennsylvania	12,807	W	33,605	W	NA	46,412
Undistributed	--	1,285	--	802	e 622	2,709
Total	29,178	1,285	115,035	802	e 622	146,922

e Estimate. NA Not available. W Withheld to avoid disclosing individual company confidential data.
[1] Not including pellets or other agglomerated products.
[2] Includes 65,203,461 tons of pellets produced at U.S. mines and 10,685,353 tons of foreign pellets and other agglomerates.
[3] Includes iron ore consumed in production of cement and ferroalloys, and iron ore shipped for use in manufacture of paint, ferrites and heavy media.

Table 11.—Iron ore consumed in production of agglomerates at iron and steel plants in 1973, by State

(Thousand long tons)

State	Iron ore consumed [1]	Agglomerates produced
Alabama, Kentucky, Texas	2,930	3,424
California, Colorado, Utah	2,472	2,014
Ohio and West Virginia	3,092	3,846
Illinois, Indiana, Michigan	8,236	10,823
Maryland, New York, Pennsylvania	14,131	16,758
Total	[2] 30,860	36,865

[1] Including domestic and foreign ores.
[2] Data does not add to total shown because of independent rounding.

Table 12.—Beneficiated iron ore shipped from mines in the United States [1]

(Thousand long tons and exclusive of ore containing 5% or more manganese)

Year	Beneficiated ore	Total iron ore	Proportion of beneficiated to total (percent)
1969	80,157	89,854	89.2
1970	79,779	87,176	91.5
1971	70,456	77,106	91.4
1972	72,011	77,883	92.5
1973	86,894	90,654	95.9

[1] Beneficiated by further treatment than ordinary crushing and screening. Excludes byproduct ore.

Table 13.—Production of iron ore agglomerates [1] in the United States, by type

(Thousand long tons)

Type	Agglomerate produced	
	1972	1973
Sinter, nodules, and cinder	[2] 36,702	[3] 21,465
Pellets	53,528	61,196
Total	90,230	82,661

[1] Production at mines and consuming plants.
[2] Includes 18,819 thousand tons of self-fluxing sinter.
[3] Includes 20,300 thousand tons of self-fluxing sinter.

Table 14.—Stocks of usable iron ore at mines [1] Dec. 31, by district

(Thousand long tons)

District	1972	1973
Lake Superior	8,031	4,124
Southeastern States	665	617
Northeastern States	5,215	5,336
Western States	768	798
Total	14,679	10,876

[1] Excluding byproduct ore.

Table 15.—Average value of usable iron ore[1] shipped from mines or beneficiating plants in the United States in 1973

(Dollars per long ton)

Type of ore	District			
	Lake Superior	South-eastern	North-eastern	West-ern
Direct-shipping, hematite and magnetite	6.48	--	--	6.91
Concentrates, hematite and magnetite	7.78	W	W	8.11
Concentrates, limonite	--	5.60	--	W
Agglomerates	14.74	--	W	15.33

W Withheld to avoid disclosing individual company confidential data.
[1] F.o.b. mine or plant. Excludes byproduct ore.

Table 16.—U.S. exports of iron ore, by country

(Thousand long tons and thousand dollars)

Country	1971		1972		1973	
	Quantity	Value	Quantity	Value	Quantity	Value
Canada	1,245	17,180	1,442	20,067	2,266	32,869
Germany, West	19	53	44	122	17	126
Japan	1,794	20,850	608	6,553	457	4,819
Mexico	(1)	1	--	--	6	70
Other	3	63	1	34	1	38
Total	3,061	38,147	2,095	26,776	2,747	37,922

[1] Less than ½ unit.

Table 17.—U.S. imports for consumption of iron ore, by country

(Thousand long tons and thousand dollars)

Country	1971		1972		1973	
	Quantity	Value	Quantity	Value	Quantity	Value
Angola	--	--	--	--	40	273
Argentina	--	--	(1)	12	31	340
Australia	1,008	12,692	687	9,245	464	5,840
Belgium-Luxembourg	--	--	--	--	17	160
Brazil	1,772	16,547	1,115	11,990	3,183	36,295
Canada	20,342	267,424	18,168	247,757	21,628	311,893
Chile	878	7,152	308	2,877	205	1,712
Liberia	1,838	16,768	2,761	22,740	2,734	23,667
Mauritania	--	--	40	687	47	418
Nigeria	52	399	85	729	--	--
Peru	1,063	12,443	1,318	15,048	1,501	19,685
Philippines	19	367	11	283	25	633
Sweden	178	2,200	273	3,952	273	4,385
Venezuela	12,953	114,176	10,926	99,951	13,148	128,169
Other	21	476	69	663	(1)	18
Total	40,124	450,644	35,761	415,934	43,296	533,488

[1] Less than ½ unit.

Table 18.—U.S. imports for consumption of iron ore, by customs district

(Thousand long tons and thousand dollars)

Customs district	1972 Quantity	1972 Value	1973 Quantity	1973 Value
Baltimore, Md	7,515	75,346	9,069	98,039
Buffalo, N.Y	2,085	33,665	2,840	44,970
Charleston, S.C	--	--	13	141
Chicago, Ill	5,505	73,300	5,248	74,064
Cleveland, Ohio	5,153	67,272	6,583	91,682
Detroit, Mich	954	13,539	1,465	20,544
Houston, Tex	478	7,285	1,005	15,517
Los Angeles, Calif	37	292	142	1,151
Mobile, Ala	3,489	34,416	4,107	43,669
New Orleans, La	838	9,269	524	6,469
Ogdensburg, N.Y	4	444	4	431
Philadelphia, Pa	9,157	94,189	11,951	131,723
Portland, Oreg	288	3,094	157	1,925
Wilmington, N.C	257	3,819	187	3,161
Other	1	4	1	2
Total	35,761	415,934	43,296	533,488

Table 19.—Iron ore, iron ore concentrates and iron ore agglomerates:[1] World production by country

(Thousand long tons)

Country[2]	1971	1972	1973 p
North America:			
Canada[3]	r 42,957	39,653	48,955
Mexico[4]	4,624	5,009	5,107
Panama	--	76	e 80
United States[5]	80,762	75,434	87,669
South America:			
Argentina	278	248	215
Bolivia (exports)	6	51	2
Brazil e	42,000	41,400	57,000
Chile	11,048	8,504	9,253
Colombia	435	409	472
Peru	8,691	9,266	8,823
Uruguay	3	1	4
Venezuela	20,000	18,173	21,682
Europe:			
Albania e 6	400	e 450	510
Austria	4,105	4,067	4,144
Belgium	92	111	120
Bulgaria	2,954	3,156	e 2,950
Czechoslovakia	1,584	1,555	1,673
Denmark	15	15	15
Finland[7]	864	979	880
France	54,980	53,396	53,372
Germany, East[8]	313	264	e 250
Germany, West	4,941	4,748	6,327
Hungary	676	684	670
Italy[9]	672	606	514
Luxembourg	4,436	4,051	3,722
Norway	3,992	3,860	3,847
Poland	2,045	1,630	1,391
Portugal[10]	97	42	35
Romania	3,412	3,308	e 3,350
Spain	7,213	6,605	6,792
Sweden	33,824	32,601	34,261
U.S.S.R	199,802	204,840	212,588
United Kingdom	10,067	8,906	7,011
Yugoslavia	3,666	3,897	4,685
Africa:			
Algeria	r 3,097	3,611	e 3,740
Angola	6,061	3,622	5,957
Egypt, Arab Republic of	465	421	e 423
Kenya	--	--	12
Liberia	23,028	22,153	23,170
Mauritania	8,323	9,252	10,314
Morocco	613	230	369
Rhodesia, Southern e	500	500	500
Sierra Leone	2,507	2,284	2,367
South Africa, Republic of[11]	r 10,330	11,046	10,782
Swaziland	r 2,821	1,952	2,113
Tunisia	921	876	796

See footnotes at end of table.

Table 19.—Iron ore, iron ore concentrates and iron ore agglomerates:[1] World production by country—Continued

(Thousand long tons)

Country [2]	1971	1972	1973 p
Asia:			
China, People's Republic of e	r 54,000	r 59,000	65,000
Hong Kong	160	160	148
India	33,720	34,939	34,841
Indonesia	267	262	277
Iran [12]	150	96	e 98
Japan [13]	1,398	1,326	991
Korea, North e	8,400	r 8,500	8,700
Korea, Republic of	496	484	586
Malaysia	r 920	512	e 530
Philippines	r 2,294	2,170	2,219
Taiwan	--	28	e 30
Thailand	39	27	36
Turkey	2,047	1,928	2,515
Oceania:			
Australia	61,119	62,812	83,367
New Zealand [14]	567	1,358	2,147
Total	r 774,677	r 766,150	850,752

e Estimate. p Preliminary. r Revised.

[1] Insofar as availability of sources permit, data in this table represent the nonduplicative sum of marketable iron ore, iron ore concentrates and iron ore agglomerates produced by each of the listed countries. Moreover, concentrate and agglomerates produced from imported ores are excluded, under the assumption that the ore from which they are produced has been credited as marketable ore in the country where it was mined.

[2] In addition to the countries listed, Cuba and North Vietnam may produce iron ore but definitive information on output, if any, is not available.

[3] Shipments, dry tons, including byproduct ore.

[4] Calculated from reported iron content assuming a grade of 60% iron.

[5] Includes byproduct ore.

[6] Nickeliferous iron ore.

[7] Includes magnetite concentrate, pelletized iron oxide (from pyrite sinter) and roasted pyrite (purple ore).

[8] Includes "roasted ore", presumably pyrite sinter, not separable from available sources.

[9] Excludes iron oxide pellets produced from pyrite sinter.

[10] Includes manganiferous iron ore.

[11] Includes byproduct magnetite as follows in thousand long tons: 1971—2,193, 1972—2,952, 1973—2,958; and manganiferous iron ore (20% to 35% iron, 15% to 30% manganese) as follows in thousand long tons: 1971—179, 1972—100, 1973—65.

[12] Year beginning March 21 of that stated.

[13] Concentrates including concentrate derived from iron sand as follows in thousand long tons: 1971—581, 1972—539, 1973—274.

[14] Largely concentrates from magnetite-titanium sands.

Iron and Steel

By Horace T. Reno [1]

The iron and steel industry of the world operated at practical capacity throughout 1973. World production of raw steel [2] ingots and castings reached a record 766 million tons. The United States regained its lead as the world's leading steel producer as it produced a record 151 million tons compared with the 144 million tons produced in the Soviet Union. Demand for steel exceeded the supply in all parts of the world, and, except in the United States, the United Kingdom, and other countries where prices were controlled, prices advanced substantially as sellers' markets developed.

According to the American Iron and Steel Institute (AISI), domestic steel mill shipments totaled a record 111 million tons, 17 million more than the record set in 1969. Shipments to all major markets exceeded those of 1972. Steel service centers and the automobile and construction industries received 20% more steel in 1973 than they did in 1972, and shipments to makers of containers and capital goods producers were nearly 18% more. The largest increase in shipments to any single market was a 53% increase to oil and gas drillers.

U.S. exports of steel mill products increased 40% compared with those of 1972; steel mill imports decreased 14%. It was apparent that the reversal in the U.S. foreign trade pattern would have been even more marked had U.S. producers been able to increase their output. AISI reported the steel industry's total revenue at $21 billion, an increase of 32% compared with revenue in 1972, and net income totaled $924 million, an increase of 77% from the $523 million net income in 1972. Net income in 1973 was 4.4% of total revenue compared with 3.3% in 1972. Despite the improved financial position of the domestic steel industry, the shortage of capital available for expanding productive capacity continued.

The high production rate for steel in 1973 brought many problems. The coke supply, which was already curtailed by inability of producers to meet environmental standards, did not equal the demand, and the quality of coke available on the market was not up to standard. In many instances steel output was limited by the supply of fuel oil, natural gas and railroad cars, and there was not enough zinc to produce all the galvanized steel needed to meet demand. Many producers resorted to rationing their output among regular customers and selectively adjusted their product mix to emphasize high-profit items. A shortage of steel to make roof bolts for use in coal mines and of steel to make drill stems and oil well casings caused most concern.

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[1] Physical scientist, Division of Ferrous Metals—Mineral Supply.

[2] The term raw steel, as used by the American Iron and Steel Institute, includes ingots, steel castings, and continuously cast steel. It corresponds to the term crude steel as used by the United Nations.

Table 1.—Salient iron and steel statistics

(Thousand short tons)

	1969	1970	1971	1972	1973
United States:					
Pig iron:					
Production	95,003	91,293	81,382	r 88,876	100,929
Shipments	95,472	91,272	81,332	r 89,053	101,239
Exports	44	310	34	15	15
Imports for consumption	405	249	306	637	446
Steel:[1]					
Production of raw steel:					
Carbon	124,832	117,411	107,007	117,698	132,747
Stainless	1,569	1,279	1,263	1,564	1,889
All other alloy	14,861	12,824	12,173	13,979	16,163
Total	141,262	131,514	120,443	133,241	150,799
Index[2]	111.0	103.4	94.7	104.5	118.5
Total shipments of steel mill products	93,877	90,798	87,038	91,805	111,430
Exports of major iron and steel products	5,788	7,657	3,526	3,546	4,962
Imports of major iron and steel products[3]	14,528	13,861	18,744	18,158	15,610
World production:					
Pig iron	453,000	475,000	474,000	r 503,000	556,000
Raw steel (ingots and castings)	633,000	655,000	640,000	r 693,000	766,000

r Revised.
[1] American Iron and Steel Institute. Includes ingots, continuous cast steel, and all other cast forms.
[2] Based on average production in 1967 as 100.
[3] Data not comparable for all years.

PRODUCTION AND SHIPMENTS OF PIG IRON

Domestic production of pig iron totaled 100.9 million tons in 1973, an increase of 12 million tons or 13.6% more than that produced in 1972. Average production of pig iron per blast-furnace-day decreased to 1,771.7 tons compared with 1,789.6 tons in 1972 and 1,654.3 tons in 1971 according to AISI. A total of 143 blast furnaces were in blast at the beginning of the year, including 2 that produced ferroalloys. At yearend the total number in blast had increased to 164, with 2 producing ferroalloys. There were 214 producing furnaces at the beginning of the year, and 203 at yearend, of which 3 were being relined and 1 was rebuilt.

Metalliferous Materials Consumed in Blast Furnaces.—For each ton of pig iron produced in 1973, an average of 1.676 tons of metalliferous materials was consumed in blast furnaces. Total net iron ore consumed in blast furnaces including agglomerates was 159.2 million short tons. The total tonnage of iron ore including manganiferous ore consumed by agglomerating plants at or near the blast furnaces in producing 41.3 million tons of agglomerates was 34.9 million tons. The remainder consisted of mill scale, coke, limestone, dolomite, and small amounts of other materials. Domestic pellets charged to the blast furnaces totaled 72.5 million tons, and sinter charged was 44.4 million tons. Pellets and other agglomerates from foreign sources added an additional 11.7 million tons.

Blast furnace oxygen consumption totaled 21.0 billion cubic feet according to the AISI, compared with 15.5 billion cubic feet in 1972 and 13.3 billion cubic feet in 1971.

Data reported to the U.S. Bureau of Mines by the iron and steel industry showed that blast furnaces, through tuyere injection, consumed 13.3 billion cubic feet of natural gas, 4.7 billion cubic feet of coke oven gas, 270.3 million gallons of oil, 94.6 million gallons of tar, pitch, and miscellaneous fuels, and 130,608 tons of bituminous and 10,397 tons of anthracite coal in 1973.

PRODUCTION AND SHIPMENTS OF STEEL

Domestic raw steel production reached a record 151 million tons in 1973, 13% more than in 1972. The steel industry worked at practical capacity throughout most of the year.

The 1973 steel index, based on production in 1967 as 100, was 118.5 compared with 104.5 in 1972 and 94.7 in 1971. Of the total, 55.2% was produced by the basic oxygen process (BOP), 26.4% by open-hearth furnaces, and 18.4% by electric furnaces.

Shipments of steel products for the year were up 21.4%, from 91.8 million tons in 1972 to 111.4 million tons in 1973. The distribution of steel shipments to markets was changed little from the distribution in 1972, with service centers and the automotive industry each accounting for approximately 20% of the total.

Materials Used in Steelmaking.—Metallics charged to domestic steel furnaces in 1973, per ton of steel produced, averaged 1,259 pounds of pig iron, 1,104 pounds of scrap, and 32 pounds of iron ore, including agglomerates. In 1972, comparable quantities were 1,246 pounds of pig iron, 1,103 pounds of scrap, and 32 pounds of iron ore.

According to AISI, steelmaking furnaces consumed 618,268 tons of fluorspar, 2.4 million tons of limestone, 7.8 million tons of lime, and 0.9 million tons of other fluxes. Oxygen consumption in steelmaking totaled the equivalent of 215.1 billion cubic feet compared with 189.5 billion in 1972.

CONSUMPTION OF PIG IRON

Pig iron consumed in steelmaking totaled 94.9 million tons. Basic oxygen converters consumed 68.08 million tons; open hearths, 25.48 million tons; and electric furnaces, 1.38 million tons. An additional 2.74 million tons was consumed by iron foundries and miscellaneous users, primarily for charging cupola furnaces. Also, approximately 2.2 million tons in the form of molten metal was used in making ingot molds and direct castings.

PRICES

At the beginning of 1973, steel prices were beginning to reflect a worldwide boom in the industry. European steel prices rose at a record rate. Reinforcing bars that had sold in European markets for approximately $115 per ton early in December 1972 were selling for $150 per ton by the end of January. Price increases in the United Kingdom and Japan lagged behind the rapid increase in the European Common Market countries; but the Japanese raised their steel export prices in February to offset the 10% devaluation of the dollar, and the British Steel Corp. raised its steel prices 9.5% in mid-April. Canadian steel prices in general followed the upward trend of steel on the world market although apparently moderated somewhat by proximity to the United States.

Prices quoted by domestic steel producers were governed by phase 2 price controls. In January, the Price Commission approved a weighted average 4½% increase in the price of steel plates at the request of National Steel Corp. Leading producers increased the price of tinplate about 4% as phase 2 ended and five producers increased the quoted price of merchant basic iron to $82.75 per net ton f.o.b. the plant. Producers of stainless tool and high-speed steels increased their prices 4% to 8% in March to recover the cost resulting from rising scrap, ferroalloy, and energy prices.

Most of the major steel producers planned to raise the base price of steel $8 to $12 per ton on June 15 to 17 but were prevented from doing so by the Cost of Living Council issuing a 60-day price freeze which was to end August 12. Essentially all producers gave 30-day notice to the Cost of Living Council in August that they planned to increase steel prices when permitted to do so in the middle of September. The Council approved only a 2½% increase effective October 1 and another 2½% effective January 1, 1974.

The price control action of the Cost of Living Council triggered widespread reevaluation by steel producers of their product mix. Seeking greater profitability, producers eliminated many low-profit forms of steel from their operations. Rod stock to make roof bolts used in coal mines and tubular steel used in casing oil wells were among the low-profit steels eliminated. The Cost of Living Council granted an exception on the price of rods to make roof bolts on November 20, and a petition for exemption from price controls for oil country goods was pending at the end of the year.

On November 30, major steel producers gave a 30-day notice of intention to increase their prices approximately 6½% on January 1, 1974. Late in December the Council agreed to adjustment of price freezes for certain steel items to reflect increased costs in iron and steel scrap incurred between June 1, 1973, and December 31, 1973.

The composite price of pig iron, according to Iron Age, increased from $71.96 per short ton at the end of January 1973 to $78.16 at the end of December, and the composite price for finished steel increased slightly from $187.26 in January to $188.64 per short ton in December.

FOREIGN TRADE

United States trade in steel mill products at the beginning of 1973 was not greatly affected by the worldwide boom in the steel industry. According to AISI, steel imports into the United States in the first month established a January record, but after the first month, the pattern of U.S. foreign trade in steel reversed, and for the entire year exports of steel mill products were 41% more than in 1972, while imports were 14% less. Some U.S. mills refused orders from foreign companies. Devaluation of the dollar on February 9 accelerated the changing pattern of U.S. steel foreign trade, and by March, Japanese and European steel producers reportedly were pricing themselves out of U.S. markets.

The changing trade pattern greatly eased the burden imposed by the voluntary restraint arrangement which limited steel exports to the United States from Japan, the United Kingdom, and European Community (EC) countries. Officials of some U.S. companies discussed formation of a United States trading combine to promote steel trade in a manner similar to that or the equivalent of Japanese trading companies which have successfully promoted Japanese steel throughout the world. Opening of the Soviet Union and the People's Republic of China to steel imports may have been the first step in steel trade between the United States and Communist countries. The Soviets sought help in providing steels suitable for consumer goods and the worldwide shortage of steel provided the economic climate in which U.S. trade with the Soviet Union could develop and flourish.

Data compiled by AISI indicated that U.S. imports of steel mill products from Japan were 12½% less than in 1972. Total steel imports from EC countries were 16% less; from Belgium-Luxembourg imports decreased 22.8%; from France 20%; from West Germany 7%; from the Netherlands 3%; from Italy 49%; and from the United Kingdom 18%. Steel mill products imported from Canada for consumption in the United States in 1973 were 7% less than in 1972.

The U.S. Tariff Commission closed six cases brought under the Anti-Dumping Act of 1921 relating to iron and steel products being sold in U.S. markets at less than fair value: (1) It determined there was no injury or likelihood of injury to domestic industry from deformed concrete reinforcing bars from Mexico, which were being sold, or likely to be sold, at less than fair value within the meaning of the Anti-Dumping Act of 1921; (2) the Commission, on being advised by the Treasury Department that iron and sponge iron powders from Canada were being, or likely to be, sold in the United States at less than fair value, scheduled public hearings December 11 to determine whether an industry in the United States was being, or was likely to be, injured, by reason of such importation; (3) the Commission determined that stainless steel wire rod imported from France was being, or was likely to be, sold at less than fair value, to injure an industry in the United States; (4) the Commission determined that the domestic industry was not injured, or likely to be injured, by cold-rolled stainless steel, sheet and strip from France; (5) the Commission discontinued its antidumping investigation of injury to domestic industry from high-speed tool steel from Sweden being sold at less than fair value; and (6) the Commission determined that a domestic industry was being injured by sale of stainless steel plate from Sweden which was being sold in the United States at less than fair value.

In investigations preliminary to Tariff Commission actions, the U.S. Treasury Department determined that pig iron from Brazil was not being sold in the United States at less than fair value, but that steel wire rope from Japan had been sold in the United States for less than fair value.

WORLD REVIEW

The steel industry of the world, with very few exceptions, operated at practical capacity throughout most of 1973. The industry produced 765.8 million tons of raw steel—a record. Record production was matched by a record demand. Shortages of steel mill products developed in most marketing areas. The steel industry of North America was at the forefront in producing steel as the industries of Canada and Mexico were as active as those of the United States, continuing the high production rate started in 1972. In South America, the steel boom was not as noticeable as in other parts of the world because the newly developing steel industries had not yet produced sufficient steel to meet demand. Steel supply in the EC and Other Western European countries, as in North America, did not meet demand. Labor troubles and a fuel shortage in the United Kingdom prevented the British Steel Corp. from contributing to continental European markets. State-owned steel producers in Eastern European countries operated as usual on their planned schedule, but the steel industry of Asia, dominated by producers in Japan, lagged somewhat behind the rest of the world in reaching capacity output.

NORTH AMERICA

Canada.—Canadian steel companies produced almost 15 million tons of crude steel—a record. Its steel imports exceeded exports by approximately 1 million tons; so the Canadian indicated crude steel equivalent consumption in 1973 was a record 15.6 million tons. Reportedly, Canadian shipments of rolled steel products were up for most categories compared with those for 1972. Notable increases were to building contractors, up 49%; automotive and aircraft industries, up 29%; natural resources and extractive industries, up 24%; and the railway industry, other than cars and locomotives, up 18%.

All Canadian steel producers modernized or expanded their iron and steelmaking facilities.[3]

Algoma Steel Corp. Ltd. installed its second basic oxygen steelmaking furnace. It had a continuous slab-casting plant under construction and installed various new finishing facilities and ancillary equipment for the new facilities.

Dominion Foundries & Steel Ltd. (DOFASCO) was in the process of rebuilding and recommissioning its No. 1 blast furnace, rebuilding stoves for the No. 2 blast furnace, and a back-draft stack for the No. 3 blast furnace. The company installed fast-roll change equipment on seven finishing stands at the hot mill with various ancillary and emission control equipment.

Interprovincial Steel & Pipe Corp. Ltd. installed a new melt shop and a 125-ton ultra-high-power furnace split shell. It added two soaking pits and a spiral pipe mill.

Sidbec-Dosco Ltd. started operating its Midrex reduction plant on April 11.[4]

The Steel Co. of Canada, Ltd. (STELCO), completed an 80-ton electric arc furnace at its McMaster works and installed a 4-strand continuous casting machine. At its Swanson works it added two heat-treating lines, and constructed numerous ancillary equipment. At its Hilton works, it constructed additional gas-cleaning equipment, a BOF shop, and an addition to BOF teaming facilities and provided oxygen enrichment for its E blast furnace.

Mexico.—The Mexican iron and steel industry produced 5.2 million tons of steel in 1973, an increase of 6% compared with that in 1972. The industry was plagued by shortages of iron, fuel, and electric power, and therefore did not grow at the rate experienced since World War II. Demand for all steel products throughout the year was at a high level, and in the last quarter of the year, delivery schedules were delayed from 75 to 90 days, and several

[3] Iron and Steel Engineer. Annual Review Issue. V. 50, No. 1, January 1974, p. D8.
[4] Schneider, V. B. Iron and Steel. Can. Min. J., v. 95, No. 2, February 1974, pp. 124–126.

fabricating concerns shutdown their plants because they could not obtain steel.

Planning of the Las Truchas complex at Melchor Ocampo in the State of Michoacán continued as bids were asked for basic oxygen and blast furnaces and for continuous casting equipment.

The expansion program of Hojalata y Lámina, S.A. (HYLSA), in Monterrey also progressed as planned. Its new direct reduction plant was scheduled to begin operation to produce 457,000 tons of sponge iron per year early in 1974.

Fundidora de Monterrey reviewed bids for its $110 million expansion program including a basic oxygen furnace, an iron ore pelletizing plant, a reheating furnace, and new rolling mill equipment.[5]

Officials of Altos Hornos de Mexico S.A. (AHMSA) visted Japan seeking financial and technical cooperation to expand AHMSA steelmaking operations, establish a new integrated steelworks on the Pacific Coast, and acquire a stainless steel line.[6]

SOUTH AMERICA

The Thirteenth Latin American Iron and Steel Congress and the Fourteenth General Assembly of the Latin American Iron and Steel Institute (ILAFA) met in Buenos Aires, Argentina, November 12–15. The meeting had been planned for October 22–25 in Santiago, Chile, but was rescheduled because of the economic and political turmoil in that country. The Congress and ILAFA have the common objective of taking advantage of the potentials that Latin American countries have to construct steel complexes which will provide the impetus for a more vigorous economic and social environment in all of South America.

The Congress was of particular significance to Latin American countries. It enabled the participants to discuss mutual problems and obtain information on the most advanced techniques which could be adapted for future installations in their countries. It was organized under three general themes to develop these objectives: (1) A technical session devoted to examining trends in the expansion of Latin American steel plants; (2) a study of methods for combating pollution of the atmosphere and of the seas and rivers; and (3) a review of general industrial engineering problems oriented to maximum production and optimum working conditions without inconvenience to the surrounding life.

Argentina.—Demand for steel mill products in Argentina continued to increase at a rapid rate. The domestic steel industry could not supply the needed steel, so a purchasing team of officials from the Government-owned Sociedad Mixta Siderúrgica Argentina (SOMISA) was formed to seek steel in European countries, the United States, and Japan.

The Argentine Government authorized SOMISA to expand raw steel production to 4 million tons.[7] The expansion program was to involve modifying an existing blast furnace, redesigning of a planned furnace for increased volume, adding an additional Linz-Donawitz (LD) converter and a wide plate mill. Total cost was estimated at $200 million.

SOMISA contracted with Corporacion Minera de Bolivia (COMIBOL) for 50,000 tons of iron ore from the Mutún deposits in southeast Bolivia. Reportedly 15,000 tons of Mutún iron ore concentrate tested satisfactorily at the SOMISA San Nicolas works.[8]

Bolivia.—The Bolivian Government and Bolivia's national iron and steel company Empresa Siderurgica Boliviana S.A. (SIDERSA) actively promoted exploitation of the Mutún iron ore deposits. Through trade with Argentina and Brazil, the Government was considering a three-country cooperative project to build an iron ore mining and iron and steel plant industrial complex which would involve Bolivian iron ore and natural gas, electric power from major dams planned on the Paraguayan-Argentine and Paraguayan-Brazilian borders, and Brazilian markets.[9]

Brazil.—Despite the rapidly expanding iron and steel industry in Brazil, the supply of iron and steel products was not keeping

[5] U.S. Bureau of Mines. Iron and Steel: Mexico. Mineral Trade Notes, v. 70, No. 10, October 1973, pp. 10–11.

[6] Saito, F. Mexican Steel Mission Seeking Japanese Financial Technical Aid. Am. Metal Market, v. 80, No. 96, May 16, 1973, pp. 4–7.

[7] U.S. Bureau of Mines. Iron and Steel: Argentina. Mineral Trade Notes, v. 70, No. 6, June 1973, pp. 4–5.

[8] U.S. Embassy, La Paz, Bolivia. State Department Airgram A–32, Feb. 15, 1974, 2 pp.

[9] U.S. Embassy, La Paz, Bolivia. State Department Airgrams A–369, Jan. 10, 1974; 10 pp.; A–074, Apr. 26, 1974, 2 pp.; and A–117, June 1, 1973, 4 pp.

pace with demand in 1973, and it became apparent that this situation would continue to erode the Nation's international reserve position. Brazil's need for iron and steel has been underestimated in the past, but the shortage and new forecasts resulted in the Government taking steps to increase Brazil's iron and steel productive capacity rapidly.

Plans were announced to build an integrated steel plant to produce 1 million tons of raw steel per year by 1978 and 2 million tons per year by 1980.[10]

A plant to produce semifinished steel at Tubarão was planned by Kawasaki Steel Corp. of Japan at the request of the Brazilian Government. The proposed plant was to be owned 51% by the Government with the remainder being owned by Kawasaki Steel Corp. and one other foreign concern.

The Brazilian Government officially asked Nippon Steel Corp. and Kawasaki Steel Corp. to consider establishing large integrated steelworks at São Luís and at Tubarão. The projects suggest a 3-million-ton steelworks at Tubarão and an initial 5-million-ton mill at São Luìs with Italian and Brazilian partners.[11]

Brazilian officials negotiated with the Bolivian Government to participate in establishing an industrial development center in southeastern Bolivia to take advantage of existing natural gas and raw material deposits. In return for obtaining Bolivian natural gas, Brazil agreed to provide a market for some of the steel mill products.

Among expansion programs at existing steel plants, Cia. Siderúrgica Paulista (COSIPA) was building a second blast furnace at Piassaguara near Santos; Usina Siderúrgica de Bahia S.A. (USIBA) was engaged in an expansion program that will eventually include three electric-arc furnaces and two or three sponge iron plants. The first electric arc furnace was started early in the year. A HyL plant to produce sponge iron was under construction. Aços Finos Piratini S.A. at Porto Alegre began producing steel with two new electric-arc furnaces operating on scrap. An SL-RN rotary kiln was under construction.[12]

Chile.—The iron and steel industry of Chile did not follow the pattern of rapidly increasing production experienced in other steel-producing Latin American countries in 1973. A 12-day strike at Cía. de Acero del Pacífico (CAP) and economic and political turmoil in the first three quarters of the year were the principal reasons for the lessening in steel output. There was marked improvement in CAP operations in the last quarter. Company officials attributed the improvement to comparative stability and labor discipline which followed the change of Government in September.[13]

EUROPEAN COMMUNITY

France.—The French iron and steel industry produced 27,849,000 tons of raw steel in 1973, about 5% more than in 1972. Production in oxygen furnaces continued to increase as 14,488,000 tons was produced, and production by the Thomas process continued to decline as only 6,788,000 tons was produced in Thomas steel furnaces and 3,608,000 tons was produced in open-hearth furnaces, about the same as in 1972. Electric steelmaking continued to increase; 2,922,000 tons was produced in electric-arc furnaces, and 35,000 tons was produced in electric-induction furnaces.

The No. 4 blast furnace of Union Sidérurgique du Nord de la France (Usinor) at Dunkirk was blown in. The No. 4 furnace is the largest in France with a capacity of 10,000 tons per day. It raised Dunkirk's ironmaking capacity to 6.9 million tons per year. In view of this large supply of hot metal, Creusot-Loire added a sixth hot-metal transfer car for transferring hot metal between Usinor's Dunkirk blast furnaces and Les Dunes steelworks at Creusot-Loire.[14]

Construction of the integrated steel complex at Fos proceeded on schedule. A slabbing mill was completed in October, and the 83-inch continuous hot-strip mill was completed early in December. The French Government provided additional funds to assure success of the projects. Additional funding brought the Government's total share in the project to about one-third.[15]

[10] Wall Street Journal. Three Japan Firms to Have 16.7% Stake in Brazil Steel Mill. V. 182, No. 40, Aug. 27, 1973, p. 7.

[11] Saito, F. Integrated Steelworks Deal on the Fire in Brazil. Am. Metal Market, v. 80, No. 212, Nov. 1, 1973, pp. 1, 17.

[12] Iron and Steel Engineer. Annual Review. Developments in the Iron and Steel Industry During 1973. V. 51, No. 1, January 1974, pp. D22–D23.

[13] U.S. Embassy, Santiago, Chile. State Department Airgram A-80, Apr. 3, 1974, 12 pp.

[14] Metal Bulletin. Dunkirk Blast Furnace. No. 5804, June 1, 1973, p. 27.

[15] Page D5 of work cited in footnote 12.

Italy.—The Italian steel industry produced 23 million tons of raw steel in 1973, 6% more than it produced in 1972. The record output did not meet demand by more than a million tons. The imbalance strengthened plans for construction of the fifth integrated steel plant to be built in Kioia Tauro (Calabria) in southern Italy. The proposed plant would be operated by Finanziaria Siderurgica (Finsider) whose officials apparently have decided that the plant will use prereduced iron ore from Brazil.[16]

Italian steelmakers, despite being principally Government-owned, continued to experience difficulty with the environmentalists. Most of the opposition to the plant at Gioia Tauro came because it was to be in an area primarily agricultural. Ecologists opposed expansion of Italsider's steel mill at Bagnoli because of gas emissions from sintering plants and coke ovens.[17]

Luxembourg.—Luxembourg's iron and steel industry produced a record 6.5 million tons of steel in 1973. The industry continued to be the driving force in the Luxembourg economy. It accounted for 25% of the gross national product, 45% of industrial production, and 69% of industrial exports. The industry is the largest single employer in Luxembourg. Approximately 95% of the steel produced in Luxembourg was exported.[18]

Luxembourg's labor unions and its steel industry signed a 2-year contract providing a 13.6% increase in average wages. The contract was signed on the last day of 1973.[19]

Netherlands.—The steel industry of the Netherlands produced 6.2 million tons of steel in 1973 approximately the same as in 1972. The industry was caught in the energy crisis and asked U.S. Government assistance in determining the status of its orders for coking coal in the United States. Energy was only one of the steel industry problems, the Hoogovens-IJmuiden works was closed by a labor strike in the first part of the year, and environmentalists continued to oppose expansion on the reclaimed Maasvlakte area near Rotterdam.

United Kingdom.—The British steel industry produced 29 million tons of steel in 1973, thus continuing its recovery from the trauma of nationalization and founding of the British Steel Corp. (BSC) in April 1967. BSC had a profitable year, the first in its existence; nevertheless, the industry fell far short of meeting demand, and its operations were seriously interrupted by major strikes. Many consumers were forced to buy imported steel at prices $50 to $100 per ton higher than quoted by BSC.

BSC and the independent steelmakers of Great Britain became members of the European Coal and Steel Community on January 1. Under Community regulations national governments cannot subsidize their steel industries, but the United Kingdom was allowed until April 30 to withdraw its support from the industry and thus permit prices to reflect a nonsubsidized operation. British steel prices were increased an average of 9½% effective May 1. Nevertheless, British steel remained the least expensive in the world markets as BSC operated at the approximate break-even point.

The British Government released a 10-year development program for BSC which will involve investment of more than $7 billion over the next 10 years and give the corporation raw steelmaking capacity of 39 million tons per year early in the 1980's. Specific details of the plan were not released, but the general program was to expand and modernize the steel industries in Scotland and Wales, close some of the smaller operations in the northern region of England, and concentrate the bulk of the steelmaking at Port Talbot in South Wales, Ravenscraig in Scotland, Llanwern in Wales, and Scunthrope and Teeside in England.

The market for steel in the United Kingdom was exceptionally strong throughout the year, and there were reports of a steel black market wherein domestic consumers bought British steel and resold it abroad. The rapidly developing need for steel in offshore oil and gas platforms in the North Sea amplified the shortage.

Independent steel producers in Great Britain have been closely affected by the

[16] U.S. Embassy, Rome, Italy. State Department Airgram A-508, Aug. 29, 1973, 16 pp.
[17] U.S. Consulate, Naples, Italy. State Department, Airgram A-11, July 9, 1973, 3 pp.
[18] U.S. Embassy, Luxembourg, Luxembourg. State Department Airgram A-22, Apr. 10, 1974, 9 pp.
[19] U.S. Embassy, Luxembourg, Luxembourg. State Department Airgram A-1, Jan. 8, 1974, 5 pp.

position and policies of BSC and its treatment by the Government. Rational planning by independent steelmakers has been prevented because they do not know whether they would remain as private companies or be brought into the nationalized combine. Nevertheless, the private sector of the steel industry has grown and prospered since 1967. Production of high-speed and tool steels was completely in the private sector in 1973 as BSC had relinquished its interest in 1972. The nature of the private sector made it the leader in developing iron and steel scrap supplies and alternate sources of iron raw materials. Moreover, steelmakers in the private sector took the lead in investigating direct reduction and pelletization of iron ore for use principally in electric-arc furnaces.[20]

West Germany.—West German steelmakers completely recovered from the depression of 1971 and 1972. In 1973 they produced almost 55 million short tons of raw steel, 40 million tons of pig iron, and 40 million tons of finished steel.

West German steel mill operators and the Metalworkers Union for Land Nord Rhine-Westphalia, the principal steel producing area of the Federal Republic of Germany, approved a new wage contract December 31, 1973, wherein the steelworkers obtained a pay raise of 11% plus additional fringe benefits. Owing to economic uncertainty, the new contract was to be only 10½ months.

Iron ore smelting in West Germany followed the pattern of large blast furnaces similar to that in Japan and the U.S.S.R. as four large blast furnaces were blown in during the year. The largest was the 45.9 foot (14 meter) hearth-diameter stack blown in early February at the August Thyssen-Hütte's Schwelgern works; however, operation of the furnace has caused trouble with the environmentalists because of the noise and fume emmision problems. A 39.3 foot (12 meter) diameter hearth furnace was blown in at the Bremen works of Klöckner Werke A.G. That furnace and a hot strip mill was built with the cooperation of the Nippon Steel Co. of Japan. The fourth largest furnace in West Germany with a hearth diameter of 37.7 feet (11.5 meters) was blown in by Friedrich Krupp Hüttenwerke A.G. at Rheinhausen.

WESTERN EUROPE

Austria.—The Austrian iron and steel industry operated at capacity throughout 1973, producing 4,672,000 short tons of steel compared with the 4,486,000 short tons produced in 1972. The Austrian Parliament approved a merger of Austria's two major nationalized steel concerns effective January 1. Vereinigte Österreichische Eisen und Stahlwerke, A.G. (Vöest) and Österreichische-Alpine Montangesellschaft A.G. were merged into one company, and two specialty steel producers, Gebrüder Böhler & Co. A.G. and Schoeller-Bleckmann Stahlwerke A.G., became wholly-owned subsidiaries of the new company.[21]

A third LD section with three 110-ton vessels was started up at the Linz works of Austria's Vöest-Alpine.[22]

Portugal.—The Government of Portugal authorized construction of a ministeel mill near Oporto.[23]

Sweden.—The steel industry in Sweden should be considered in two segments—one producing ordinary carbon steel and the other specialty steels. The carbon steel segment did not keep pace with the overall world activity in 1973, but the specialty steel segment improved its position as a supplier of stainless and alloy steels.

Despite the unimpressive record of Swedish steel industry, the Government announced plans for a large new steelworks to be constructed at Luleå on the northeast coast at an estimated cost between $500 and $600 million. It was expected that most of the plant's steel would be exported to continental European countries. As Sweden affiliated with the EC and the Coal and Steel Community in 1972, the new plant might benefit from Sweden's agreements with the Community.[24]

EASTERN EUROPE

U.S.S.R.—The U.S.S.R. produced a record 144 million tons of raw steel in 1973

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[20] Steel Times. BISPA—The Private Sector Reports. V. 202, No. 3, March 1974, pp. 218–240.

[21] U.S. Embassy, Vienna, Austria. State Department Airgram A–149, Mar. 15, 1973, 3 pp.

[22] Metal Bulletin. Linz Expansion. No. 5815, July 10, 1973, p. 28.

[23] U.S. Embassy, Lisbon, Portugal. State Department Airgram A–77, May 4, 1973.

[24] U.S. Embassy, Stockholm, Sweden. State Department Telegram 2426, July 13, 1973, 3 pp.

but lost its place as the world's largest producer to the United States. Steel demand in the U.S.S.R. continued to exceed supply. According to the Soviet news agency, Novosti Press, the Communist Council for Mutual Economic Assistance planned an integrated steel plant with a 10-million-ton-per-year capacity in the Kursk basin of central U.S.S.R.

The Soviet Union's largest blast furnace at Lipetsk, in the center of European Russia, was lit in February 1973. Reportedly, the furnace had a working volume of 4,185 cubic yards (3,200 cubic meters) and capacity to produce 2.2 million tons of pig iron annually.

AFRICA

Egypt, Arab Republic of.—The technical and commercial directors of Arab iron and steel member companies of the Arab Iron and Steel Union met at Khartoum, Sudan, to study the present and future situation of the iron and steel industry in the Arab world and to lay the foundations of cooperation and coordination between the Arabic companies.[25] The Soviet Union continued its interest and help to Arabic steel industries by providing assistance for installing a third blast furnace at the Helwan Iron and Steel Mill in the Arab Republic of Egypt.[26]

South Africa, Republic of.—The iron and steel industry of South Africa operated at capacity throughout 1973 producing 6,207,000 short tons compared with 5,886,000 tons produced in 1972. The South African Iron and Steel Industrial Corp. (ISCOR) decided to delay planned expansion of its Newcastle steelworks 5 or 6 years and meet the shortfall by expanding the existing Vanderbijlpark plant. Under the new plans the Vanderbijlpark mill will be producing 6 million tons of steel annually by 1983, while Newcastle will produce only 3 million tons.

Highveld Steel and Vanadium Corp. Ltd. announced plans to expand its Witbank works in the Transvaal by adding a sixth kiln, a fifth submerged arc-smelting furnace, and a fourth continuous casting machine.[27]

Japanese and U.S. steel companies negotiated with ISCOR to produce semifinished steel for export.

ASIA

A meeting of the Sub-Committee on Metals and Engineering of the Committee on Industry and Natural Resources of the United Nations, Economic Commission for Asia and the Far East (ECAFE) was held August 22 to 28, 1973, in New Delhi, India. It reviewed the development and growth of the iron and steel industry of the ECAFE region and noted the rapid growth of the industry in Japan, Australia, and New Zealand which accounted for 26 million tons in 1960 and 100 million tons in 1970. The developing countries increased output of iron and steel from 12 million tons to only 25 million tons during the same period. ECAFE developing countries continued to be net importers of steel, but Malaysia, Indonesia, and the Republic of Korea planned possible expansion. Scarcity of raw materials—iron ore, coking coal, limestone, dolomite, and power—restrict development of steel industries in other ECAFE developing countries.[28]

China, People's Republic of.—Apparently China's iron and steel industry operated at a high level of activity in 1973 following the pattern of the industries in the Western World. Similarly, China's domestic industry was unable to meet the demand. The Chinese imported increasing quantities of foreign steel and negotiated with the Japanese to supply steel rolling mills and continuous casting equipment to increase their own output.[29]

India.—The iron and steel industry of India produced only slightly more steel in 1973 than it did in 1972 despite the addition of the Bokaro plant to list of active producers. The five major steel plants, Bhilai (Madhya Pradesh), Durgapur (West Bengal), Rourkela (Orissa), Tata Iron and Steel Co. (Bihar), and the Indian Iron and Steel Co. (West Bengal) produced at less than 70%

[25] Arab Steel. Recommendations of the First Conference. No. 4, March 1973, pp. 15–16.

[26] U.S. Bureau of Mines. Iron and Steel: Arab Republic of Egypt. Mineral Trade Notes, v. 70, No. 3, March 1973, p. 5.

[27] E & MJ. New Growth Slated for Highveld Steel and Vanadium. V. 174, No. 5, May 1973, p. 40.

[28] U.S. Embassy, New Delhi, India. State Department Airgram A–332, Sept. 12, 1973, 7 pp.

[29] American Metal Market. Japan-China Pact Is Near on Rolling Mills for Latter. V. 80, No. 196, Oct. 9, 1973, p. 7.

of capacity. However, plants of the Hindustan Steel Co. (Rourkela, Bhilai, and Durgapur) produced 12% more steel in 1973 than they did in 1972.[30]

The major causes for underutilization of the steel plants were shortages of power, coking coal, and coke-oven gas; technical problems and lack of coordination in supply; transportation problems in coal, iron ore, limestone; and labor problems (particularly at Durgapur and West Bengal). The severity of the transportation problem forced the Tata steel plant at Jamshedpur to shutdown some production units because coal was not being delivered owing to a slowdown by railway workers.[31]

There was a serious shortage of steel mill products, and according to the steel ministry, industrial concerns held large stocks of steel in their inventories. The severity of the shortage was indicated by the disparity between free market and controlled prices. Prices for plates, joists, and channels in the free market were more than twice the controlled prices.

The iron section at the Bokaro steel plant operated throughout the year and at yearend had produced more than 800,000 tons of pig iron. Steel production in a 100-ton converter started on December 27, 1973.[32]

The Steel Authority of India Limited (established in 1972 as part of an effort to reshape and revitalize the steel industry) was registered in New Delhi on January 24, 1973.

An international symposium on "Science and Technology of Sponge Iron and Its Conversion to Steel" was held at the National Metallurgical Laboratory, Jamshedpur, February 19 to 21, 1973. The symposium may have instigated a Government decision to license more ministeelworks and not to impose regulations on ministeelworks using electric-arc furnaces.

Indonesia.—The Indonesian Government approved an $18 million joint venture between Marubeni Corp. and Toshin Steel Co. Ltd. of Japan, Sims Consolidated Ltd. of Australia, and N. V. Sumera to establish an integrated steel mill in Jakarta.[33]

Iran.—The Iranian Government actively promoted its domestic steel industry to take advantage of a surplus of inexpensive natural gas. The National Iranian Steel Corp. commissioned its first integrated steel plant at Isfahan. The Isfahan plant was built with the assistance of the Soviet Union. Its blast furnace was lit in December 1971. The corporation contracted with the Korf Co. of West Germany for a 1.2-million-ton Midrex direct-iron reduction plant to be built at Ahwaz in South Iran. Meanwhile, the Iranian Government negotiated with Swindell-Dressler Corp., a division of Pullman Inc., to construct and equip a direct-reduction plant at Isfahan. Swindell-Dressler is the agent for the HyL process developed in Mexico.

Japan.—The Japanese iron and steel industry produced 132 million tons of crude steel in 1973, 23% more than in 1972. Basic oxygen furnaces produced 81% of the total, electric furnaces 18%, and open-hearth furnaces 2%. Ninety-nine million tons of pig iron was produced, 22% more than in 1972. According to the Japanese Iron and Steel Federation, iron and steel exports in 1973 totaled 25.6 million tons, 16% more than in 1972.[34] In the first part of the year the industry seemed to retreat from the high rate of steel production established in the last few months of 1972, but after a 2-month pause, the trend of increasing output continued. For the first time in the Japanese steel industry's history, shortage of water forced some producers to curtail their output.

Domestic demand for steel, which may have been responsible for the decreased production in the first part of the year increased rapidly. The Japanese Ministry of International Trade and Industry (MITI) asked steelmakers to restrict exports and give priority to the backlog of domestic orders. Steel prices increased markedly, responding to the imbalance between supply and demand. The Government initiated allocation to prevent domestic buyers from bidding up prices, but formal restraints were not placed on exports. It became apparent that the pattern of the industry, which had been wholly growth and export oriented, could not continue. The pricing system which

[30] U.S. Consulate, Calcutta, India. State Department Airgram A-15, Aug. 14, 1973, 16 pp.
[31] Iron and Steel Review. Editorial: Unheard of Before. V. 17, No. 7, December 1973, p. 5.
[32] Government of India, Ministry of Steel and Mines, Department of Steel, New Delhi. Report 1973–74, p. 3.
[33] U.S. Embassy, Jakarta, Indonesia. State Department Airgram A-21, Feb. 13, 1974, 5 pp.
[34] Japan Iron and Steel Exporters Association. The Current State of the Steel Industry Today and Tomorrow. No. 3, March–April 1974, p. 12.

had encouraged exports, was changed to favor domestic consumers and the industry, prodded by the Government, sought opportunities to participate in foreign steelmaking enterprises.

The Steel Committee of the Industrial Structure Council, in an interim report to MITI, advised that the iron and steel industry must redirect its investment policies.[35] The Committee recommended that the industry must strive ceaselessly to become eventually a clean industry and fit into the Nation's resources and energy plans; moreover, that in the face of the environmental and energy problems, steel exports must be moderated; and furthermore, that new steel plants in overseas locations must be positively considered. Apparently the change in policy had been expected as Japanese participation in foreign steelmaking enterprises was reported as follows: (1) Kawasaki Steel Corp. reached basic agreement with the Brazilian Government to construct a 6-million-ton-per-year steel plant in Brazil jointly with Brazilian and Italian companies; (2) Mitsubishi International, Kawasaki Steel. and Nippon Kokan Co. agreed to participate in a steel venture in Jamaica; (3) Mitsui and Co. scheduled a steel wire and rod manufacturing enterprise in Nigeria with British Ropes Ltd. of Doncaster, England; (4) Sumitomo Metal Industries Ltd. announced plans to set up a company in Saudi Arabia jointly with Nippon Steel Corp. and the Alireza group in that country to produce large-diameter welded steel pipes and to participate in Confab Industrial S.A. of São Paulo, Brazil, in a similar operation.

The Japanese steel industry lit four large blast furnaces of more than 5,232 cubic yards (4,000 cubic meters) inner volume in 1973: (1) No. 5 furnace at Fukuyama Works, Nippon Kokan KK, 47.2 feet (14.4 meters) hearth diameter, 6,039 cubic yards (4,617 cubic meters) inner volume, lit November 1973; (2) No. 4 furnace, Mizushima Works, Kawasaki Steel Corp., 47.2 feet (14.4 meters) hearth diameter, 5,651 cubic yards (4,320 cubic meters) inner volume, lit April 1973; (3) Kashima Works, Sumitomo Metal Industries, No. 2 furnace, 45.3 feet (13.8 meters) hearth diameter, 5,337 cubic yards (4,080 cubic meters) inner volume, lit March 1973; and (4) Kimitsu Works, Nippon Steel Corp., No. 3 furnace 44 feet (13.4 meters), hearth diameter, 5,314 cubic yards (4,063 cubic meters) inner volume, lit September 1973.

The No. 5 blast furnace at the Fukuyama Works was reportedly the world's largest, with expected average daily pig iron output of over 11,000 tons. Planned steelmaking facilities at the Fukuyama plant will increase its annual capacity to 13.3 million tons of pig iron and 15 million tons of crude steel, by far the largest steelmaking plant in the world.

Kawasaki Steel Corp. announced that it was operating a new prereduced pelletizing plant at its Mizushima Works. The plant recycles iron dust and scale from blast and oxygen furnaces and rolling mills to produce prereduced pellets. Reported plant capacity was 40,000 tons per month of raw pellet mix.

Saudi Arabia.—The Saudi Arabian Government and Marcona Corp. of San Francisco conducted a feasibility study of the possibility of building a steel mill on the Arabian Gulf coast which would be based on Brazilian high-grade iron ore reduced by natural gas.

Taiwan.—The Government of Taiwan announced its intention to construct a 1.5-million-ton-per-year integrated steel mill at Kaohsiung. United States Steel Engineers & Consultants, through a contract with the China Steel Corp. of Taiwan, was to provide technical services for construction of the project.[36]

OCEANIA

Australia.—Broken Hill Proprietary Co. Ltd., the only integrated steel company in Australia, produced at capacity throughout the year but was unable to cope with the rising demand of the automobile and appliance industries for hot- and cold-rolled strip and plate. Despite the shortage of steel in Australian markets, the Australian Mining & Steel Pty. Ltd. (ASM), owned equally by Armco Steel Corp. and Kaiser Steel Corp. of the United States and August Thyssen Hütte of West Germany, decided to modify plans to erect an integrated steel mill to produce 2.9 million tons of slab and 500,000 tons of plate annually. ASM's

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[35] Japan Iron & Steel Monthly. Steel Industry of the 1970. No. 225, October 1973, pp. 6–14.

[36] U.S. Embassy, Taipei, Taiwan. State Department Airgram A-34, Feb. 28, 1974, 5 pp. Wall Street Journal. Taiwan Official Sees U.S. Steel Corp. Likely as Choice to Build Mill. V. 182, No. 12, July 18, 1973, p. 4.

new plans were to construct a smaller electric furnace mill based on direct reduction of beneficiated ore at Jervis Bay in New South Wales.[37]

TECHNOLOGY

Blast Furnace.—The world's largest blast furnace was lit on November 8 at the Nippon Kokan Fukuyama Works in Japan. It had a 47.2 foot (14.4-meter) hearth diameter, was 318 feet (97 meters) high, and had 6,039 cubic yards (4,617 cubic meters) volume from stock to tap lines. The largest blast furnace in France was lit at Dunkirk on May 18 and held the world's record as the largest from May to November. It was a year of large furnaces. The largest furnace in the U.S.S.R. was lit in February. The Soviet furnace, however, did not compare with the others, having only 4,186 cubic yards (3,200 cubic meters) in working volume.

Bethlehem Steel Corp. patented a baffle nose tuyère, claimed to help solve burnout and wear problems in iron-making blast furnaces.[38]

Direct Reduction.—Direct reduction was the subject of a panel discussion at the International Iron & Steel Institute meeting held at Johannesburg, Republic of South Africa, in October. Although there was a great deal of interest in direct reduction and successful operations of direct reduction plants were reported, the consensus at the meeting was that a large-scale blast furnace is the most economical source of hot metal.

Armco Steel Corp. reported that its direct reduction plant at Houston, Tex., was completely debugged and producing at the rate of 900 tons per day. United States Steel's briquetting plant at Porto Ardaz, Venezuela, was inaugurated October 27, but Venezuelan Government officials declared that the briquets would not be permitted to leave the country while a need for them existed in Venezuela.

Fior de Venezuela S.A., (Fior) of which the Venezuelan Government was majority owner, and Lukens Steel Corp. which holds a minority interest in Fior contracted for design of a 44,000 ton-per-year fluidized bed iron ore reduction plant. The process to be used was developed by Esso Research and Engineering Co., a subsidiary of the Exxon Corp.

Swindell-Dressler Corp. contracted with the National Iranian Steel Industries Co. to design, build, and equip a plant to produce more than 1 million tons of sponge iron per year. The plant will use the HyL direct reduction process first developed and proved in Monterrey, Mexico.

Sidbec-Dosco Ltd. of Quebec commissioned a direct reduction plant, designed by the Midrex Corp., in April. The plant produced approximately 1,000 tons of direct reduced ore per day. The reduced product was fed directly to electric-arc furnaces.

Basic Oxygen Steelmaking Processes (BOP).—Steelmakers continued to favor basic oxygen steelmaking processes as a means of producing large quantities of steel, but the share of domestic BOP steel production decreased from 56% in 1972 to 55% in 1973 as the high production rate brought many open hearths back into service. United States Steel Corp. started its first bottom blown oxygen converter (Q–BOP) at the Gary, Ind., works early in the year; by May, the corporation reported the Q–BOP to be a complete success.[39] One advantage claimed for its operation was easier control of air pollution.

A study of slag-making reactions in the BOF process indicated that careful control of the flux minimizes refractory wear and slag buildup while maintaining a normal degree of desulfurization.[40]

Electric-Arc Furnaces.—Production of raw steel in the United States by electric arc furnaces in 1973 totaled 27,759,000 tons, an increase of 17% compared with production of 23,721,000 tons by electric furnaces in 1972. It is believed that most electric-furnace steelmaking operations in the United States operated at practical capacity throughout the year, although the

[37] U.S. Bureau of Mines. Iron and Steel: Australia. Mineral Trade Notes, v. 70, No. 7, July 1973, p. 10.

[38] Metal Bulletin. Bethlehem's New Invention. No. 5828, Aug. 24, 1973, p. 30.

[39] American Metal Market. U.S. Steel Managers Rave Over Q–BOP. V. 80, No. 103, May 25, 1973, pp. 1, 3.

[40] Iyengar, R. D., and F. C. Petrilli. Slag-making Reactions in the BOF Process. J. Metals, v. 25, No. 7, July 1973, pp. 21–26.

quality of scrap for feed undoubtedly decreased steel output somewhat. An estimated capacity of 32 million tons in 1972 in all probability included some furnaces under construction.

The pattern of increased use of electric-arc furnaces to make steel extended throughout the world. New furnaces were under construction in Canada, West Germany, France, and Japan. The Japanese led the world in increasing use of electric-arc furnaces, producing approximately 20 million tons of raw steel in electric furnaces, more than doubling their electric furnace output in the last 6 years.

Continuous Casting.—Continuous casting equipment in the United States apparently had marked effect on the ratio between raw steel production and steel mill shipments. Shipments in 1973 were 74% of raw steel production while they were only 69% of production in 1972. A large part of this difference was probably the result of steel mills shipping from inventory and the normal practice of not adhering to strict specifications during times of high production. Nevertheless, increased use of continuous casting in 1973 definitely improved the efficiency of the domestic steel industry.

Iron and Steel Refining.—Vacuum degassing of steel continued to receive increasing attention throughout the steel industry as consumers narrowed the tolerances allowable for alloy steels. For specialty applications, argon-oxygen decarburization (AOD) and electroslag remelting (ESR) processes were used for steels which require uniform mechanical properties throughout.

Test data on steels produced in the Lukens Steel Co.'s new ESR facility indicated that the method improved uniformity, tensile strength, ductility, and notch toughness. Lowering the concentrations of small inclusions could be directly attributable to the ESR process. The AOD process was the subject of the Extractive Metallurgy Lecture at the Annual Meeting of the Metallurgical Society of AIME.[41] An AOD vessel with sliding refractory gates to permit pouring through the bottom of the charge was commissioned at the Cabot Corp.'s Stellite Division, Kokomo, Ind.[42] Bottom pouring reportedly minimizes reentrainment of gases that had been removed previously.

Foundry.—The domestic foundry industry operated at its practical capacity throughout the year. Many founders were unable to obtain all the coke, pig iron, and scrap they needed and petitioned the Department of Commerce for priority to buy raw materials.

Research and Development.—U.S. Bureau of Mines researchers made a survey of underground injection of waste-pickle liquor from steel processing.[43] They determined that the average depth of waste pickle liquor injection wells is 4,000 feet and that injection is mostly by gravity flow. In other iron- and steel-related research at the Twin Cities Metallurgy Research Center, Bureau metallurgists investigated the fluorspar requirements in BOF steelmaking and fluorspar substitutes, and determined distribution of fluorspar in BOF products. At the Rolla Metallurgy Research Center, the use of ferrous wastes in cupola electric arc furnaces and BOF operations was studied. Studies were underway to improve utilization of ferrous metals with the general objective of producing ductile iron from blast furnace pig iron suitable for replacing steel in applications where lower strength and ductility could be tolerated. The Rolla studies included an investigation of possible methods for utilization or recovery of valuable alloy metals from stainless steel, ferroalloys, and steel wastes such as flue dust, mill scale, and grinding swarfs. At the Albany Metallurgy Research Center, continuous electric furnace steelmaking was studied to improve efficiency through the use of continuous charging and preheating of charge materials. Recycling of automotive and other ferrous scrap was investigated at the Salt Lake City Metallurgy Research Center.

Industrial researchers directed their attention to devising means of controlling steelmaking functions with computers and finding some way of overcoming the poor quality of steelmaking raw materials, principally coke and scrap iron and steel. The foundry industry was the hardest hit by poor scrap quality. Inasmuch as reactants were in short supply, the only method

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[41] Krivsky, W. A. The Linde Argon-Oxygen Process for Stainless Steel; a Case Study of Major Innovation in a Basic Industry. Met. Trans., v. 4, No. 6, June 1973, pp. 1439–1447.

[42] Iron Age. New AOD Vessel Boosts Metal Purity by Bottom Pouring. V. 212, No. 3, July 19, 1973, p. 19.

[43] Bayazeed, A. F., and E. C. Donaldson. Subsurface Disposal of Pickle Liquor. BuMines RI 7804, 1973, 31 pp.

devised by the foundrymen to overcome poor quality was to use less scrap and more foundry iron. Others researched desulfurizing iron with magnesium and use of mag-coke for desulfurizing.[44] The mag-coke apparently solved differential density problems in getting magnesium into molten iron. Reportedly, mag-coke (approximately 45% by weight magnesium) is immersed in molten iron and the thermal shielding effect of the coke controls the rate of magnesium vapor evolution, thus effectively lowering the sulfur content. Armco Steel Corporation reported that injection of powdered coal into its furnace in Ashland, Ky., was so successful that it planned to install injection equipment at its other blast furnaces. According to American Metal Market, Armco was satisfied with the coal injection. It plans to adapt other furnaces to it.[45] Experimental injection of coal into the smelting zone of a blast furnace was reported by the Bureau of Mines and others late in the 1960's. At that time, availability of inexpensive fuel oil and natural gas made coal injection economically unattractive.

An iron information center was established by Battelle Memorial Institute at its Columbus, Ohio, laboratories to serve the needs of industry in the fields of iron ore agglomeration and iron making.

[44] Fisher, P. A. Desulfurizing With Magnesium. Light Metal Age, v. 31, Nos. 5 and 6, June 1973, pp. 19–20.

[45] American Metal Market. V. 80 No. 239, Dec. 11, 1973, p. 5.

Table 2.—Pig iron produced and shipped in the United States, in 1973, by State

(Thousand short tons and thousand dollars)

State	Production	Shipped from furnaces		Average value
		Quantity	Value	
Alabama	3,836	3,949	294,965	74.69
Illinois	7,919	7,964	585,054	73.46
Indiana	17,128	17,078	1,261,281	73.85
Ohio	18,405	18,514	1,468,509	79.32
Pennsylvania	22,699	22,686	1,725,854	76.08
California, Colorado, Utah	5,595	5,611	444,046	79.14
Kentucky, Maryland, Texas, West Virginia	11,951	11,923	757,115	63.50
Michigan, Minnesota	8,006	8,007	611,119	76.32
New York	5,390	5,507	395,471	71.81
Total	100,929	101,239	7,543,414	74.51

Table 3.—Foreign iron ore and manganiferous iron ore consumed in manufacturing pig iron in the United States, by source of ore

(Thousand short tons)

Source	1972 [1]	1973 [2]
Australia	r 904	550
Brazil	r 279	1,397
Canada	1,815	2,219
Chile	324	648
Venezuela	4,058	5,707
Other countries	r 764	1,609
Total	r 8,144	12,130

r Revised.

[1] Excludes 18,475 tons used in making agglomerates.

[2] Excludes 21,573 tons used in making agglomerates.

Table 4.—Pig iron shipped from blast furnaces in the United States, by grade[1]

(Thousand short tons and thousand dollars)

Grade	1972			1973		
	Quantity	Value		Quantity	Value	
		Total	Average per ton		Total	Average per ton
Foundry	r 1,433	r 98,608	r 68.81	6,785	465,367	68.59
Basic	r 83,798	r 6,494,709	r 77.50	90,189	6,771,346	75.08
Bessemer	1,269	94,835	74.73	1,321	97,308	73.66
Low-phosphorus	105	7,966	75.87	148	11,497	77.38
Malleable	1,998	149,348	74.75	2,349	161,347	68.69
All other (not ferroalloy)	450	35,472	78.83	447	36,549	81.77
Total	r 89,053	r 6,880,938	r 77.27	101,239	7,543,414	74.51

r Revised.
[1] Includes pig iron transferred directly to steel furnaces at same site.

Table 5.—Number of blast furnaces (including ferroalloy blast furnaces) in the United States, by State

State	Jan. 1, 1973			Jan. 1, 1974		
	In blast	Out of blast	Total	In blast	Out of blast	Total
Alabama	9	8	17	8	3	11
California	4	--	4	4	--	4
Colorado	4	--	4	4	--	4
Illinois	10	7	17	14	1	15
Indiana	21	5	26	25	1	26
Kentucky	2	--	2	2	--	2
Maryland	7	3	10	10	--	10
Michigan	8	1	9	9	--	9
Minnesota	--	2	2	--	2	2
New York	8	6	14	10	3	13
Ohio	29	14	43	31	11	42
Pennsylvania	32	23	55	36	18	54
Texas	1	1	2	2	--	2
Utah	2	1	3	3	--	3
West Virginia	4	--	4	4	--	4
Total	141	71	212	162	39	201
Ferroalloy blast furnaces	2	--	2	2	--	2
Grand total	143	71	214	164	39	203

Source: American Iron and Steel Institute.

Table 6.—Iron ore and other metallic materials, coke and fluxes consumed, and pig iron produced in the United States, by State

(Thousand short tons)

Year and State	Metalliferous materials consumed: Iron and manganiferous ores: Domestic	Foreign	Agglomerates	Net ores and agglomerates [1]	Net scrap [2]	Miscellaneous [3]	Net total	Net coke	Fluxes	Pig iron produced	Metalliferous materials consumed per ton of pig iron made: Net ores and agglomerates [1]	Net scrap [2]	Miscellaneous [3]	Total	Coke and fluxes consumed per ton of pig iron: Net coke	Fluxes
1972:																
Alabama	550	1,832	4,283	6,572	143	7	6,722	2,995	r 723	4,086	1.608	0.035	0.002	1.645	0.733	r 0.177
Illinois	W	--	10,193	11,315	211	327	11,853	4,303	1,133	r 7,197	1.572	.029	.045	1.647	.598	.157
Indiana	W	W	22,675	23,772	222	673	24,667	8,073	1,866	r 15,330	1.551	.014	.044	1.609	.527	.122
Michigan and Minnesota	122	W	10,226	10,226	458	58	10,742	4,060	941	6,929	1.476	.066	.008	1.550	.586	.136
New York	1,080	30	W	6,000	248	191	6,439	2,472	547	3,933	1.526	.063	.049	1.637	.629	r.139
Ohio	4,840	848	20,002	25,007	510	1,225	r 26,741	10,266	3,354	16,363	1.528	.031	.075	1.634	.627	r.205
Pennsylvania	5,238	3,161	23,618	31,612	761	r 1,231	r 33,605	12,755	2,408	20,355	1.553	.037	r.060	r 1.651	.627	.118
California, Colorado, Utah	r 1,485	W	W	r 7,652	r 143	r 123	r 7,918	r 2,798	r 840	r 4,745	r 1.613	r.030	r.026	r 1.669	r.590	r.177
Maryland, West Virginia, Kentucky, Texas	W	W	13,833	15,621	30	765	16,416	6,116	1,220	9,938	r 1.572	.003	.077	r 1.652	.615	.123
Total	r 16,082	r 8,144	r 116,082	r 137,777	r 2,726	r 4,600	r 145,103	r 53,838	r [4] 13,032	r 88,876	r 1.550	r.031	r.052	r 1.633	.606	r.147
1973:																
Alabama	291	W	3,852	6,106	98	2	6,206	2,614	633	3,836	1.592	.026	.001	1.618	.681	.165
Illinois	W	W	11,421	12,529	306	329	13,163	4,515	1,148	7,919	1.582	.039	.042	1.662	.570	.145
Indiana	W	W	24,911	26,387	367	1,125	27,879	8,989	1,931	17,128	1.541	.021	.066	1.628	.525	.113
Michigan and Minnesota	487	29	11,980	12,369	250	417	13,035	4,621	1,081	8,006	1.545	.031	.052	1.628	.577	.135
New York	1,757	26	W	8,280	183	421	8,884	3,545	734	5,390	1.536	.034	.078	1.648	.658	.136
Ohio	4,352	1,830	22,001	27,528	810	1,613	29,951	9,685	3,849	18,405	1.496	.044	.088	1.627	.526	.209
Pennsylvania	6,152	3,806	25,307	34,784	1,664	1,051	37,499	13,462	2,470	22,699	1.532	.073	.046	1.652	.593	.109
California, Colorado, Utah	5,533	--	W	12,865	170	103	13,138	3,290	1,058	5,595	2.299	.030	.018	2.348	.588	.189
Maryland, West Virginia, Kentucky, Texas	386	3,314	15,238	18,378	230	755	19,363	7,390	1,664	11,951	1.538	.019	.063	1.620	.618	.139
Total	20,943	12,130	128,838	159,226	4,078	5,816	169,118	58,111	[5] 14,568	100,929	1.578	.040	.058	1.676	.576	.144

r Revised. W Withheld to avoid disclosing individual company confidential data; included with "Total."

[1] Net ores and agglomerates equal ore plus agglomerates plus flue dust used minus flue dust recovered.

[2] Excludes home scrap produced at blast furnaces.

[3] Does not include recycled material.

[4] Fluxes consisted of the following: 6,391 limestone, 198 burnt lime, 6,104 dolomite, and 338 other fluxes excluding 4,803 limestone, 13 burnt lime, 3,418 dolomite, and 113 other fluxes used in agglomerate production at or near steel plants and an unknown quantity used in making agglomerates at mines.

[5] Fluxes consisted of the following: 7,588 limestone, 51 burnt lime, 6,557 dolomite, and 471 other fluxes excluding 5,490 limestone, 3,437 dolomite, and 155 other fluxes used in agglomerate production at or near steel plants and an unknown quantity used in making agglomerates at mines.

Table 7.—Steel production in the United States, by type of furnace[1]

(Thousand short tons)

Year	Open hearth[2]	Basic oxygen converter	Electric	Total
1969	60,894	60,236	20,132	141,262
1970	48,022	63,330	20,162	131,514
1971	35,559	63,943	20,941	120,443
1972	34,936	74,584	23,721	133,241
1973	39,780	83,260	27,759	150,799

[1] Excludes castings produced by foundries not covered by AISI.
[2] Basic and acid open-hearth production data reported separately in previous years.

Source: American Iron and Steel Institute.

Table 8.—Metalliferous materials consumed in steel furnaces[1] in the United States

(Thousand short tons)

Year	Iron ore		Agglomerates		Pig iron	Ferro-alloys[2]	Iron and steel scrap
	Domestic	Foreign	Domestic	Foreign			
1969	710	2,121	487	512	84,187	1,775	74,343
1970	502	1,889	465	476	81,797	1,641	66,451
1971	308	1,166	294	320	76,422	1,447	63,308
1972	236	850	401	192	r 83,569	1,655	r 68,345
1973	163	1,320	656	243	94,933	1,907	83,228

r Revised.
[1] Basic oxygen converter, open-hearth furnace, and electric furnace.
[2] Includes ferromanganese, spiegeleisen, silicomanganese, manganese metal, ferrosilicon, ferrochromium alloys, and ferromolybdenum.

Table 9.—Consumption of pig iron[1] in the United States, by type of furnace

Type of furnace or equipment	1971		1972		1973	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Basic oxygen converter	52,023	66.2	60,233	69.9	68,077	69.7
Open hearth	23,574	30.0	22,375	25.9	25,477	26.1
Electric	825	1.0	961	1.1	1,379	1.4
Cupola	1,865	2.4	2,264	2.6	2,276	2.3
Air	60	.1	139	.2	57	.1
Other furnaces[2]	204	.3	254	.3	402	.4
Total	78,551	100.0	86,226	100.0	97,668	100.0

[1] Excludes molten pig iron used for ingot molds and direct castings.
[2] Includes vacuum melting furnaces and miscellaneous melting processes.

Table 10.—Consumption of pig iron[1] in the United States, by State

(Thousand short tons)

State	1973
Alabama	3,748
Connecticut	16
Georgia	5
Illinois	7,873
Indiana	16,997
Iowa	32
Kansas	2
Kentucky	1,768
Louisiana	(2)
Maine	(2)
Massachusetts	25
Michigan	8,598
Missouri	21
Montana	(2)
Nebraska	(2)
Nevada	(2)
New Jersey	63
New York	5,189
North Carolina	8
Ohio	17,992
Oklahoma	7
Oregon	7
Pennsylvania	21,601
Rhode Island	3
Tennessee	110
Texas	1,324
Vermont	1,899
Washington	4
Wisconsin	122
Undistributed[3]	14,120
Total	101,534

[1] Includes molten pig iron used for ingot molds and direct castings.
[2] Less than ½ unit.
[3] Includes California, Colorado, Florida, Maryland, Minnesota, New Hampshire, South Carolina, Utah, Virginia, and West Virginia.

Table 11.—U.S. exports of major iron and steel products

Products	1969 Quantity (short tons)	1969 Value (thousands)	1970 Quantity (short tons)	1970 Value (thousands)	1971 Quantity (short tons)	1971 Value (thousands)	1972 Quantity (short tons)	1972 Value (thousands)	1973 Quantity (short tons)	1973 Value (thousands)
SEMIMANUFACTURED										
Ingots and other primary forms:										
Puddled bars and pilings, blocks, lump and other primary forms of iron or steel, n.e.c	8,643	$1,015	11,425	$1,721	1,916	$291	543	$107	38	$18
Blooms, billets, ingots, slabs, sheet bars, and roughly forged pieces	1,810,490	142,767	3,169,563	270,368	873,526	78,191	415,392	37,860	546,991	63,023
Coils for rerolling	421,531	61,911	340,630	49,903	14,347	7,646	85,473	13,816	43,702	10,732
Blanks for tubes and pipes, iron or steel	12,159	1,400	2,175	280	2,334	271	2,807	311	3,737	394
Total	2,252,823	207,093	3,523,793	322,272	892,123	86,399	504,215	52,094	594,468	74,167
Bars, rods, angles, shapes and sections:										
Wire rods	98,245	16,348	151,062	18,541	62,843	8,415	122,894	16,169	89,786	15,303
Bars, rods, and hollow-drill steel	215,674	51,797	216,362	48,415	129,872	38,550	166,794	43,735	239,617	70,368
Concrete reinforcing bars	86,762	11,592	92,534	12,134	40,540	6,089	22,417	3,141	151,535	29,788
Angles, shapes, and sections	170,424	29,261	212,405	37,554	164,031	33,111	124,825	25,756	272,519	58,708
Plates and sheets:										
Steel plates	25,441	12,603	27,011	14,021	23,353	12,062	15,063	10,262	29,392	17,405
Steel sheets	1,040,381	146,923	1,268,386	190,079	583,015	82,982	396,860	66,679	658,430	152,935
Black plate	49,723	6,789	67,931	9,133	85,202	13,527	58,831	8,830	95,272	16,344
Iron and steel plates, n.e.c	403,715	66,152	292,803	56,835	161,921	37,492	198,653	42,184	473,911	97,176
Tinplate and terneplate	339,606	52,264	341,275	61,844	224,120	43,101	290,255	55,272	419,275	95,344
Tinplate circles, cobbles, strip and scroll	26,080	2,577	23,910	2,628	9,716	1,186	4,565	552	24,151	2,678
Hoop and strip	11,595	38,160	376,068	73,311	129,128	42,619	404,211	76,146	268,762	83,076
Total	2,567,646	434,466	3,069,747	524,495	1,613,741	319,134	1,805,368	348,726	2,722,650	639,125
MANUFACTURED										
Rails and railway track construction materials:										
Rails	56,105	7,903	63,980	10,143	50,291	8,489	105,396	16,042	108,965	19,184
Joints and tie plates	8,323	1,585	7,976	1,620	8,948	2,563	9,348	2,173	14,302	3,667
Sleeper and track material of iron or steel, n.e.c	8,708	3,507	9,873	4,104	4,599	2,073	4,767	2,231	4,253	2,044
Wire, cables, ropes, bands, and slings	82,480	37,172	72,868	38,479	62,746	38,282	69,819	43,581	88,469	58,639
Tubes, pipes, and fittings:										
Cast-iron pressure pipe and fittings	22,782	6,639	22,034	8,173	15,481	8,095	32,586	11,399	27,897	13,575
Cast-iron soil pipe and fittings	9,637	2,701	11,537	3,690	8,288	2,813	4,797	1,744	6,208	2,894
Steel tube and pipe fittings, unions, and flanges	18,344	27,397	22,262	33,214	21,707	36,679	17,517	32,001	21,451	40,176
Steel tube and pipe fittings, welded	11,641	18,708	12,840	19,469	10,546	18,306	7,155	14,082	7,621	15,186
Malleable iron tube and pipe fittings, n.e.c	2,087	2,290	1,560	1,857	2,407	2,764	2,282	2,688	3,747	5,449
Electrical conduit fittings of iron or steel	12,317	7,965	10,453	7,971	7,289	8,880	3,907	5,646	4,611	6,710
Iron tube and pipe fittings, n.e.c	7,191	10,562	7,935	10,414	7,820	12,063	8,394	14,535	11,315	20,827
Seamless tubes and pipe	251,996	99,235	243,835	100,295	222,768	99,542	236,633	104,810	376,997	162,263
Welded, clinched, or riveted tubes and pipes	73,767	28,992	100,721	40,579	111,564	44,709	187,548	60,504	207,893	77,658

Finished structural iron and steel	116,054	55,013	142,462	67,727	117,275	63,023	89,622	77,989	219,228	153,914
Castings and forgings	205,612	79,452	255,671	102,726	295,619	114,320	371,888	129,629	439,298	173,576
Storage tanks, lined or unlined	15,245	11,426	16,539	11,174	15,582	10,494	14,885	9,628	14,804	11,764
Nails, tacks, staples, and spikes, n.e.c	9,349	7,058	7,667	6,499	7,720	5,835	9,045	7,364	12,822	10,928
Bolts	27,753	23,829	26,069	23,634	23,837	23,348	26,062	24,962	31,394	31,677
Nuts	6,567	9,647	5,846	8,684	5,780	9,374	8,845	11,322	10,865	14,613
Screws, rivets, washers	22,003	26,546	21,271	27,622	19,939	27,342	26,401	33,270	32,272	42,850
Total	967,961	467,627	1,063,399	528,074	1,020,206	538,994	1,236,897	605,600	1,644,412	867,594
Grand total	5,788,430	1,109,186	7,656,939	1,374,841	3,526,070	944,527	3,546,480	1,006,420	4,961,530	1,580,886

Table 12.—U.S. imports for consumption of pig iron, by country

Country	1971 Quantity (short tons)	1971 Value (thousands)	1972 Quantity (short tons)	1972 Value (thousands)	1973 Quantity (short tons)	1973 Value (thousands)
Australia	171	$10	--	--	--	--
Brazil	25,620	1,111	212,590	$8,044	57,634	$2,726
Canada	270,048	15,402	415,293	25,068	387,168	26,132
Germany, West	--	--	--	--	62	4
Guyana	--	--	--	--	154	10
Japan	--	--	61	2	--	--
South Africa, Republic of	10,481	441	8,987	403	39	2
Sweden	--	--	--	--	569	51
United Kingdom	--	--	1	1	--	--
Total	306,320	16,964	636,932	33,518	445,626	28,925

Table 13.—U.S. imports for consumption of major iron and steel products

Products	1969 Quantity (short tons)	1969 Value (thousands)	1970 Quantity (short tons)	1970 Value (thousands)	1971 Quantity (short tons)	1971 Value (thousands)	1972 Quantity (short tons)	1972 Value (thousands)	1973 Quantity (short tons)	1973 Value (thousands)
Iron products:										
Cast iron pipes and tubes	26,108	$5,883	18,491	$5,534	12,356	$2,516	11,870	$3,923	6,248	$1,873
Malleable cast-iron fittings	8,287	3,568	9,690	4,229	11,962	6,164	13,777	7,668	8,493	6,018
Bars of wrought iron	617	153	428	123	226	65	386	120	243	84
Castings and forgings	24,311	6,283	15,819	5,446	12,975	5,219	15,395	6,447	23,059	11,138
Total	59,323	15,887	44,428	15,332	37,519	13,964	41,428	18,158	38,043	19,113
Iron and steel products:										
Ingots, blooms, billets, slabs, and sheet bars	195,176	37,514	170,647	29,917	274,407	37,191	261,694	38,242	172,305	30,801
Bars of steel:										
Concrete reinforcement bars	470,807	40,563	202,699	21,200	514,813	49,809	358,223	34,969	286,428	43,875
Solid and hollow steel bars	903,813	119,522	727,742	115,027	1,027,768	153,831	1,049,173	176,744	954,286	197,426
Hollow drill steel	5,412	2,036	4,212	1,687	2,392	1,088	4,606	1,285	2,637	1,376
Plates and sheets:										
Black plate	11,657	1,684	5,753	987	7,452	1,371	2,010	438	3,323	651
Steel plate	1,201,523	120,201	968,677	124,109	1,572,560	198,952	1,685,654	239,412	1,348,767	216,255
Steel sheets	4,873,519	557,044	5,271,943	710,623	7,746,573	1,069,372	6,959,182	r 1,043,449	5,837,588	986,676
Plates and sheets of iron or steel	809	692	250	404	417	550	532	441	709	549
Plates, sheets and strip of iron or steel[1]	30,320	6,204	50,963	10,100	75,970	14,255	64,179	13,945	71,737	16,976
Strip of iron or steel	96,162	32,921	92,335	37,934	114,902	43,678	135,400	51,850	116,415	52,306
Tinplate and terneplate	300,664	51,339	327,725	59,066	417,691	80,595	522,466	107,870	470,345	105,630
Structural iron and steel	1,517,373	171,669	1,300,847	186,885	1,637,154	231,060	1,745,696	247,426	1,375,223	228,419
Angles, shapes, and sections	522,601	48,747	416,124	50,030	550,350	61,971	562,864	65,598	457,457	63,044
Wire rods of steel	1,260,890	129,803	1,055,570	131,810	1,538,288	187,607	1,402,904	188,789	1,418,256	229,258
Sheet piling	65,957	6,854	52,335	6,189	89,208	10,605	94,781	12,909	81,248	12,303
Pipes, tubes and fittings	1,702,536	267,062	1,976,749	341,441	1,888,942	340,425	1,887,376	368,846	1,681,112	383,372
Bail ties of iron or steel	23,881	3,193	15,353	2,279	21,047	3,307	17,166	3,067	15,334	3,011
Steel castings and forgings	18,539	8,352	14,039	6,660	12,958	5,275	24,000	9,186	19,020	7,137
Rails and railway track construction materials	67,581	10,630	72,306	11,323	68,863	11,034	74,820	12,350	77,697	14,741
Wire:										
Round wire	563,265	110,097	505,164	116,561	530,194	125,722	522,205	138,618	525,893	173,701
Other wire	146,127	29,021	143,726	33,875	135,737	33,464	155,770	43,807	87,740	32,217
Nails	317,257	55,642	259,833	52,522	308,105	60,428	379,912	86,572	345,121	97,332
Total	14,295,869	1,810,790	13,634,992	2,050,129	18,535,791	2,721,590	17,910,613	r 2,885,813	15,348,641	2,897,056
Advanced manufactures:										
Bolts, nuts, rivets and washers	172,904	58,795	181,559	73,718	170,966	67,235	206,428	88,259	223,192	129,043
Grand total	14,528,096	1,885,472	13,860,979	2,139,179	18,744,276	2,802,789	18,158,469	r 2,992,230	15,609,876	3,045,212

r Revised.
[1] Includes plates, sheets and strips of iron or steel, electrolytically coated or plated; 1969, 17,528 tons ($2,764); 1970, 35,610 tons ($5,802); 1971, 67,359 tons ($11,583); 1972, 58,681 tons ($11,797); 1973, 63,787 tons ($14,020).

Table 14.—Pig iron:[1] World production by country

(Thousand short tons)

Country[2]	1971	1972	1973 p
North America:			
Canada	8,616	9,364	10,511
Mexico[3]	2,598	2,948	3,059
United States	81,382	88,876	100,929
South America:			
Argentina	r 949	936	886
Brazil	r 5,251	5,842	6,031
Chile	505	536	505
Colombia[4]	268	318	291
Peru[4]	158	180	285
Venezuela[4]	568	591	587
Europe:			
Austria	3,141	3,137	3,313
Belgium	r 11,466	12,980	13,932
Bulgaria	1,472	1,673	e 1,800
Czechoslovakia[5]	8,775	9,216	e 9,400
Denmark	244	220	e 110
Finland	r 1,141	1,305	1,556
France	19,731	20,449	21,782
Germany, East[6]	2,235	2,371	2,427
Germany, West[7]	32,685	34,930	40,191
Greece[8]	321	375	564
Hungary	2,172	2,253	e 2,300
Italy	9,410	10,378	11,059
Luxembourg[4]	5,057	5,149	5,612
Netherlands	4,144	4,728	5,188
Norway[8]	682	714	772
Poland	7,764	8,037	e 8,500
Portugal	r 391	391	e 425
Romania	4,830	5,390	e 6,100
Spain	5,321	6,528	6,913
Sweden[3]	3,040	2,792	3,040
Switzerland	35	31	30
U.S.S.R	97,276	r e 100,638	e 104,587
United Kingdom	16,823	16,903	18,382
Yugoslavia	1,669	2,006	2,155
Africa:			
Algeria e	77	77	77
Egypt, Arab Republic of	550	330	276
Morocco e	11	11	11
Rhodesia, Southern[4]	309	320	320
South Africa, Republic of	r 4,416	4,860	e 4,900
Tunisia	108	158	e 172
Asia:			
China, People's Republic of e[9]	30,000	r 33,000	36,000
India	7,382	7,944	e 8,300
Iran	--	e 600	441
Israel e	40	40	40
Japan	80,187	81,632	99,216
Korea, North e[9]	2,800	2,900	3,000
Korea, Republic of	2	2	35
Malaysia e	r 72	r 90	110
Taiwan	84	89	165
Thailand	15	13	16
Turkey	972	1,251	e 1,000
Oceania:			
Australia	r 6,754	7,156	8,441
New Zealand (all sponge iron) e	110	110	110
Total	r 474,009	502,768	555,852

e Estimate. p Preliminary. r Revised.

[1] Table excludes all ferroalloy production except where otherwise noted.

[2] In addition to the countries listed, North Vietnam and Zaire presumably have facilities to produce pig iron, but available information is inadequate to make reliable estimates of output levels.

[3] Includes sponge iron output as follows in thousand short tons: Mexico: 1971—743; 1972—865; 1973—831; Sweden: 1971—192; 1972—196; 1973—208.

[4] Includes ferroalloys, if any are produced.

[5] Includes blast furnace ferroalloys.

[6] May include ferroalloys.

[7] Includes blast furnace ferroalloys except ferromanganese, ferrosilicon and speigeleisen.

[8] Includes blast furnace ferroalloys, if any are produced.

[9] Includes ferroalloys production.

Table 15.—Raw steel:[1] World production by country

(Thousand short tons)

Country[2]	1971	1972	1973 p
North America:			
Canada	12,170	13,073	14,755
Cuba e	154	154	154
Mexico	4,212	4,884	5,177
United States[3]	120,443	133,241	150,799
South America:			
Argentina	r 2,111	2,320	2,373
Brazil[4]	r 6,612	7,185	7,881
Chile	720	695	616
Colombia	358	412	378
Peru	198	200	397
Uruguay	16	14	13
Venezuela	1,018	1,243	1,170
Europe:			
Austria	4,366	4,486	4,672
Belgium	13,717	16,019	17,113
Bulgaria	2,147	2,338	2,476
Czechoslovakia	13,304	14,029	14,550
Denmark[5]	519	549	495
Finland	1,130	1,605	1,780
France	25,197	26,515	27,849
Germany, East	5,897	6,250	6,493
Germany, West	r 44,437	48,177	54,587
Greece	525	e 551	e 551
Hungary	3,428	3,608	3,673
Ireland	88	85	121
Italy	19,237	21,842	23,143
Luxembourg	5,777	6,016	6,531
Netherlands	5,603	6,157	6,200
Norway	973	1,010	1,061
Poland	14,041	14,855	15,496
Portugal	r 454	468	507
Romania	7,499	8,158	8,996
Spain	r 8,592	10,531	11,839
Sweden	5,810	5,795	6,242
Switzerland	586	598	612
U.S.S.R	132,979	138,438	144,403
United Kingdom	r 26,647	27,912	29,405
Yugoslavia	2,705	2,853	2,950
Africa:			
Algeria	e 40	72	e 72
Egypt, Arab Republic of	282	r e 340	e 320
Morocco e	1	1	1
Rhodesia, Southern e	176	r 220	330
South Africa, Republic of	5,424	5,890	6,207
Tunisia	r 132	165	176
Uganda	18	12	e 11
Asia:			
Bangladesh	e 110	e 45	68
Burma e	r 23	r 22	22
China, People's Republic of e	23,000	25,000	28,000
India	r 7,091	7,641	e 7,700
Iran	--	--	220
Israel e	130	130	130
Japan	97,617	106,814	131,535
Korea, North e	2,600	2,800	2,900
Korea, Republic of[4]	520	645	1,280
Lebanon e	20	r 17	17
Malaysia e	r 72	r 90	110
Philippines e	95	r 276	276
Singapore	136	210	e 220
Taiwan	432	504	559
Thailand	132	201	e 210
Turkey	1,237	1,590	1,333
Oceania:			
Australia	7,426	7,433	8,468
New Zealand	r 75	r 173	209
Total	r 640,459	692,557	765,832

e Estimate. p Preliminary. r Revised.
[1] Steel formed in first solid state after melting suitable for further processing or sale.
[2] In addition to the countries listed, North Vietnam produces raw steel, but information is inadequate to make reliable estimates of output levels.
[3] Data from American Iron and Steel Institute (AISI). Excludes steel produced by foundries not reporting output to AISI but reported to Bureau of Census as follows (in thousand tons): 1971—1,583; 1972—1,607; 1973—1,880.
[4] Ingots only.
[5] Apparently excludes shipyards' production of steel castings.

Iron and Steel Scrap

By D. H. Desy [1]

Consumption of iron and steel scrap reached a record high in 1973, reflecting record production of raw steel. Strong domestic and foreign demand for scrap drove prices to new highs and prompted the Department of Commerce to impose export controls in the latter half of the year. In spite of these controls, exports also reached record levels in 1973.

Research and development, both by the Bureau of Mines and by industry, continued on the utilization of the ferrous fraction of municipal scrap for making iron and steel. A small quantity of this material was recycled by the steel industry.

Legislation and Government Programs.—Because of rising prices and very high domestic and foreign demand for ferrous scrap during the year, representatives of the steel industry requested the Department of Commerce to impose export restrictions on that commodity. On May 22, 1973, the Department of Commerce imposed reporting requirements on all ferrous scrap exports to provide a basis for an estimate of demand levels for the balance of 1973. This estimate indicated a continuing high demand for ferrous scrap.

Under the authority of the Export Administration Act of 1969, the Department of Commerce on July 2, 1973, imposed licensing requirements on all exports of ferrous scrap. Licenses valid for 60 days were granted for orders of 500 tons or over that were accepted before July 2, 1973 for delivery during the balance of 1973. Licenses for orders under 500 tons were at first granted for export to all countries regardless of when these orders were accepted. These licenses were later restricted to Canada and Mexico for the months of October, November, and December 1973, and monthly quotas were established.

In December 1973, an overall export quota for ferrous scrap of 2,100,000 short tons for the first quarter of 1974 was announced by the Department of Commerce. Of this amount, 100,000 short tons were set aside for contingencies and hardships, and the balance was allocated by country following historical trade patterns.

Table 1.—Salient iron and steel scrap, and pig iron statistics in the United States

(Thousand short tons and thousand dollars)

	1972	1973
Stocks Dec. 31:		
Scrap at consumer plants	8,169	7,092
Pig iron at consumer and supplier plants	1,660	1,215
Total	9,829	8,307
Consumption:		
Scrap	93,371	103,589
Pig iron	89,140	99,816
Exports:		
Scrap (excludes rerolling material)	7,177	10,874
Value	233,395	570,011
Imports for consumption:		
Scrap (includes tinplate and terneplate scrap)	312	349
Value	14,741	19,100

AVAILABLE SUPPLY

The new supply of iron and steel scrap available for consumption at consumers' plants in 1973 was 102.5 million short tons. It consisted of 57.8 million tons of home scrap and 44.7 million tons of purchased scrap (net receipts). Compared with 1972 figures, home scrap production was up 13% and net receipts were up 11%.

[1] Physical scientist, Division of Ferrous Metals—Mineral Supply.

CONSUMPTION

Consumption of iron and steel scrap in 1973 reached a record high of 103.6 million short tons. This was an increase of 10.9% over consumption in 1972 and 9.3% above the previous high established in 1969. Manufacturers of steel ingots and castings took 82.5 million tons or 79.6% of the total. Iron foundries and miscellaneous users consumed 18.2 million tons or 17.5%, and manufacturers of steel castings consumed the remainder.

STOCKS

Consumers' stocks reported on hand as of December 31, 1973, were 7.1 million short tons, down 13% from 8.2 million tons at the end of 1972. Stocks remained between 7.8 and 8.0 million tons through August 1973, then declined to the yearend figure of 7.1 million tons.

PRICES

Prices of scrap iron and steel rose sharply during the year. At the end of November, the Iron Age composite price (Chicago, Pittsburgh, and Philadelphia) for No. 1 heavy melting steel scrap reached a record high of $81.83 per long ton, exceeding the record of $64.97 in December 1956. The composite price dropped slightly to $75.17 at the end of December 1973; this was 62.8% above the price of $46.17 at the end of December 1972.

FOREIGN TRADE

Exports of iron and steel scrap (excluding rerolling material, and ships, boats, and other vessels for scrapping) reached a record high of 10.9 million short tons in 1973, exceeding the 1970 record of 10.1 million tons by 8%, and the 7.2 million tons in 1972 by 52%. The total would probably have been higher if export licensing had not been instituted in mid-1973.

The largest exports went to Japan,

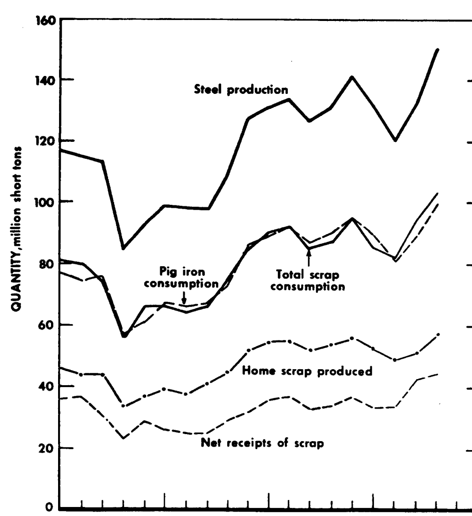

Figure 1.—Steel production (AISI); total iron and steel scrap consumption; pig iron consumption; home scrap production; and net scrap receipts.

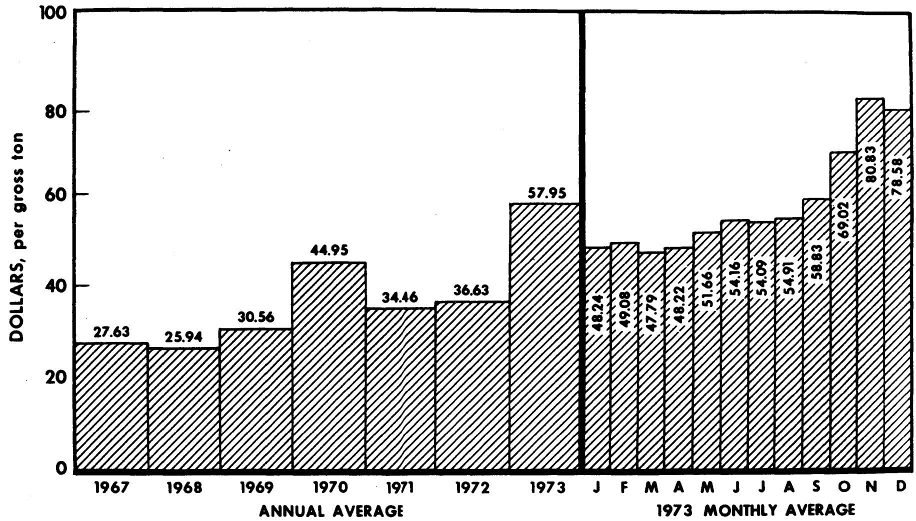

Figure 2.—Composite prices for No. 1 heavy melting scrap (Chicago, Pittsburgh, Philadelphia).

which received 42% of the total; next largest exports went to Spain and Mexico, which received 10% and 9%, respectively. Exports of ferrous scrap went to the People's Republic of China for the first time in 1973, amounting to 428,000 tons or 3.9% of the total.

No. 1 heavy melting steel scrap continued as the largest export grade, accounting for 35% of the total. Next largest export grades were shredded steel scrap and No. 2 bundles, which accounted for 19% and 11%, respectively.

WORLD REVIEW

Austria.—Domestic scrap supplies decreased about 50,000 tons from those of 1972 because of low price levels and the fact that the Government delayed approval of price increases as an anti-inflation measure.

Belgium.—High steel production, short supplies of coal, and high transportation costs have kept the demand for and price of scrap high. Scrap was imported at a rate equal to that of West Germany, about 1.5 million short tons annually.

Canada.—Because of U.S. restrictions on scrap exports, Canada canceled all export permits in August and introduced new procedures that limited scrap exports to a minimum. The Quebec Government-owned steel company, Sidbec-Dosco Ltd., has set up a subsidiary, Sidbec-Unifer, to supply it with steel scrap. The company will have authority to buy, sell, export, and process metal of all kinds. Scrap will be obtained from junk autos among other resources.

France.—Increased steel production brought consumption of scrap to an estimated 3.3 million short tons for the year compared with just over 2.2 million in 1972.

Germany, West.—Demand for scrap was high in this year of record steel production. Crude steel output rose to 54.2 million short tons, 13% over 1972; consumption of scrap was 27.6 million short tons, a 10% increase over that of 1972.

Italy.—New electric steel furnaces with total capacity of 800,000 tons per year are expected to start up by the end of 1973. Thus, demand for scrap will continue to increase.

Japan.—When export licensing of scrap iron and steel was imposed by the United States, Japan voluntarily reduced total imports from the United States in 1973 by 1 million tons (from 6.5 to 5.5 million, including scrap for reexport). The 1 million tons would be deferred to 1974. In addition, Japan agreed to spread imports evenly over the remainder of 1973. Domestic scrap prices declined somewhat at the end of the year as a result of the oil shortage. Steelmakers sought to stabilize the market by a series of measures including a coordinated import policy, a domestic distribution organization, and intermill cooperation over scrap stocks. The construction of 10 cryogenic plants for processing baled auto scrap by a Belgian process is being considered. There were approximately 10 large shredders in Japan in 1973.

Netherlands.—This country is a net exporter of scrap, most going to West Germany, France, and Belgium. With the entry of the United Kingdom into the European Community (EC), the Netherlands will be in a good position to transfer British export scrap arriving in Holland by ship to barges for shipment up the Rhine to West Germany.

Spain.—This country's expanding steel industry, which depends largely on imported scrap for its raw material, was adversely affected by restrictions on scrap exports from the U.S.A. in the second half of the year, as well as Britain's earlier export ban.

Sweden.—Scrap consumption was higher than 1972 levels, requiring increased imports, mainly from the U.S.S.R. and Poland. About 50 percent of all scrap automobile bodies are now being shredded.

United Kingdom.—Britain entered the EC on January 1, 1973; however, there will be a 2-year transition period during which some controls will be maintained on exports of ferrous scrap. One consequence of Britain's entry into the EC was the termination on July 1 of the long-standing pricing agreement between the steel industry and the scrap dealers. Export controls were tightened throughout the year, culminating on October 1 in a ban on exports of all but the lowest grades of scrap under strict licensing and quota regulations. Exports to countries outside the EC had been prohibited on May 21. Despite export controls, strong domestic demand kept prices up, though lower than in the rest of Europe.

TECHNOLOGY

The ferrous fraction of municipal waste, consisting mainly of tin-plated steel cans, is being increasingly recycled in ironmaking and steelmaking, although the percentage of the total is still small. Among the latest entries in the field is Granite City (Illinois) Steel Co., a division of National Steel, which is using cans from shredded municipal waste from St. Louis, Mo., in its blast furnace charge, at the rate of 15 pounds of scrap per ton of hot metal.[2] In New Orleans, La., steel cans obtained from a facility to be in operation in 1974 will

[2] Industry Week. Blast Furnace Joins Steel Recycling Effort. V. 176, No. 13, Mar. 26, 1973, p. 20.

be used by United States Steel in its new QBOP (bottom-blown basic oxygen process) furnace facility at Fairfield, Ala.[3]

General Motors' Central Foundry Division in Danville, Ill., has developed a method for melting bundled auto hulks without removing combustible material. The method can be used in cupolas with modern air pollution controls. The percentage of bundles used must be controlled to assure the quality of the metal produced.[4]

A cryogenic method that employs liquid nitrogen is being used in a pilot plant in Chicago to separate mixed scrap containing a significant percentage of copper, aluminum, and other nonferrous metals along with the ferrous portion.[5]

A new type of magnetic separator, specifically designed for separation of the ferrous fraction of municipal scrap has recently been made available. The new system is said to produce a much cleaner ferrous fraction than conventional magnetic separators.[6]

The Bureau of Mines continued its research efforts in the area of improving utilization of ferrous scrap and waste materials. Metallurgists at the Bureau's Albany (Oregon) Metallurgy Research Center completed a project to test the feasibility of producing electric furnace steel from the ferrous fraction of municipal waste, principally steel cans. The material was tested in the as-received, detinned, or incinerated condition; some was shredded or briquetted. Melting conditions, yield, and chemical composition were determined. Another project was concerned with the preheating and continuous charging into the electric furnace of shredded auto scrap and mixtures of scrap and prereduced iron pellets. Energy consumption, melting rate, yield, and ingot chemistry were being determined.

Scientists from the Bureau's College Park (Maryland) Metallurgy Research Center were acting as consultants to the contractors in the design and construction of a demonstration plant for the City of Lowell, Mass., to process 250 tons of incinerator residues per day. The plant is a scaled-up version of the pilot plant developed at this center, and was partially funded by a grant from the Environmental Protection Agency (EPA). Work was also continuing on refinements to the pilot plant, and residues from the Lowell, Mass., area were processed to provide data for the new plant there. Studies were continuing on methods of removing impurities from the ferrous fraction of the residues. A pilot plant for the treatment of raw refuse was essentially completed. A large number of processing tests were run and cost evaluations were made. Tin-plated cans from the treated refuse were evaluated by commercial detinning companies.

At the Bureau's Rolla (Missouri) Metallurgy Research Center, metallurgists continued to study the effects of impurities such as copper, tin, and lead in ductile cast iron (nodular cast iron). Such impurities are normally present in higher-than-desirable quantities in the ferrous fraction of municipal waste and other low grades of iron and steel scrap, and cannot be economically removed with present technology. The effects of combinations of tin and copper on the strength, ductility, and microstructure of ductile cast iron and the maximum levels and relative potency of these elements were being determined. Studies on the effects of small amounts of lead were initiated.

At the Bureau's Twin Cities Metallurgy Research Center in Minnesota, the use of ferrous waste in the cupola, electric arc furnace, and basic oxygen furnace (BOF) was being investigated. Various types of automotive scrap, including bundled, incinerated, and shredded material, were being evaluated for melting in the electric arc furnace. Yields and chemical content of harmful impurities in the product were determined. Iron-aluminum bimetallic cans were melted in the cupola, alone or in combination with shredded auto scrap, to produce a synthetic pig iron. The effect on fuel requirements, melting rates, and resid-

[3] American Metal Market. Metals Firms Opt for Waste-Recovered Scrap Buying. V. 80, No. 49, Mar. 12, 1973, pp. 7, 17.

[4] American Metal Market. GM System Melts Bundled Auto Hulks Without Removal of Combustible Parts. V. 80, No. 240, Dec. 12, 1973, p. 18.

[5] American Metal Market. Cryogenics So Successful Quadrupling of Pilot Plant Targeted for Next March. V. 80, No. 216, Nov. 7, 1973, pp. 11, 16.

[6] Secondary Raw Materials. New Magnetic System To Revolutionize Recycling of Steel Cans. V. 11, No. 11, November 1973, pp. 98–99.

ual sulfur and aluminum content of the pig iron were being determined. Preheating of shredded scrap by BOF offgases was being studied as a means of increasing the percentage of scrap that can be added to the BOF charge. A method for preparing purified iron oxide pellets suitable for blast furnace use from impure oxides from incinerator residues and incinerated automotive scrap was also being investigated.

Table 2.—Consumer stocks, receipts, production, consumption, and shipments of iron and steel scrap in 1973, by grade

(Thousand short tons)

Grade of scrap	Receipts	Production	Consumption	Shipments	Stocks Dec. 31
MANUFACTURERS OF STEEL INGOTS AND CASTINGS					
Carbon steel:					
Low-phosphorous plate and punchings	531	11	532	2	58
Cut structural and plate	660	103	782	3	48
No. 1 heavy melting steel	10,146	21,904	30,375	2,486	1,881
No. 2 heavy melting steel	2,644	1,412	4,008	93	333
No. 1 and electric furnace bundles	6,448	814	7,544	53	566
No. 2 and all other bundles	3,043	500	3,549	76	292
Turnings and borings	1,826	300	1,992	155	154
Slag scrap (Fe content)	1,563	2,346	3,658	124	240
Shredded or fragmentized	1,789	--	1,778	1	70
All other carbon steel scrap	3,744	14,957	17,491	1,220	859
Stainless steel	429	670	1,036	46	119
Alloy steel (except stainless)	538	1,939	2,399	79	189
Cast iron (includes borings)	2,577	5,151	6,364	1,346	1,120
Other grades of scrap	717	299	959	49	44
Total	36,655	50,406	82,467	5,733	5,973
Pig iron	4,768	100,542	96,604	8,327	955
MANUFACTURERS OF STEEL CASTINGS					
Carbon steel:					
Low-phosphorous plate and punchings	621	172	800	1	47
Cut structural and plate	230	13	236	5	12
No. 1 heavy melting steel	146	81	226	1	19
No. 2 heavy melting steel	13	--	13	--	--
No. 1 and electric furnace bundles	71	--	73	--	4
No. 2 and all other bundles	19	--	18	--	1
Turnings and borings	73	7	80	3	5
Slag scrap (Fe content)	1	3	3	--	--
Shredded or fragmentized	76	--	77	--	2
All other carbon steel scrap	586	306	879	11	70
Stainless steel	15	12	25	2	2
Alloy steel (except stainless)	81	69	137	15	17
Cast iron (includes borings)	166	113	285	3	30
Other grades of scrap	47	52	97	2	3
Total	2,145	828	2,949	43	212
Pig iron	66	--	64	1	8
IRON FOUNDRIES AND MISCELLANEOUS USERS					
Carbon steel:					
Low-phosphorous plate and punchings	1,222	57	1,247	14	70
Cut structural and plate	1,092	134	1,202	10	79
No. 1 heavy melting steel	455	79	485	29	32
No. 2 heavy melting steel	175	4	175	2	18
No. 1 and electric furnace bundles	435	1	423	--	28
No. 2 and all other bundles	623	14	607	--	58
Turnings and borings	724	50	722	45	57
Slag scrap (Fe content)	6	6	13	1	--
Shredded or fragmentized	567	--	562	1	30
All other carbon steel scrap	1,858	136	2,035	29	131
Stainless steel	15	--	13	--	3
Alloy steel (except stainless)	116	4	117	1	19
Cast iron (includes borings)	4,408	5,649	9,725	289	355
Other grades of scrap	440	433	846	28	27
Total	12,136	6,567	[1] 18,173	449	907
Pig iron	3,236	--	3,148	112	252

See footnotes at end of table.

Table 2.—Consumer stocks, receipts, production, consumption, and shipments of iron and steel scrap in 1973, by grade—Continued

(Thousand short tons)

Grade of scrap	Receipts	Production	Consumption	Shipments	Stocks Dec. 31
TOTAL—ALL TYPES OF MANUFACTURERS					
Carbon steel:					
Low-phosphorous plate and punchings	2,374	240	2,579	17	175
Cut structural and plate	1,982	250	2,220	18	139
No. 1 heavy melting steel	10,747	22,064	31,086	2,516	1,932
No. 2 heavy melting steel	2,832	1,416	4,196	95	351
No. 1 and electric furnace bundles	6,954	815	8,040	53	598
No. 2 and all other bundles	3,685	514	4,174	76	351
Turnings and borings	2,623	357	2,794	203	216
Slag scrap (Fe content)	1,570	2,355	3,674	125	240
Shredded or fragmentized	2,432	--	2,418	2	102
All other carbon steel scrap	6,188	15,399	20,405	1,260	1,060
Stainless steel	459	682	1,074	48	124
Alloy steel (except stainless)	735	2,012	2,653	95	225
Cast iron (includes borings)	7,151	10,913	16,374	1,638	1,505
Other grades of scrap	1,204	784	1,902	79	74
Total	50,936	57,801	103,589	6,225	7,092
Pig iron [2]	8,070	100,542	99,816	8,440	1,215

[1] Data does not add to total shown because of independent rounding.
[2] Includes all pig iron used in reporting establishments.

Table 3.—Consumption of iron and steel scrap and pig iron [1] in the United States in 1973, by type of consumer and type of furnace or equipment

(Thousand short tons)

Type of furnace or equipment	Manufacturers of steel ingots and castings [2]		Manufacturers of steel castings [3]		Iron foundries and miscellaneous users		Total all types	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
Blast furnace [4]	4,246	--	--	--	--	--	4,246	--
Basic oxygen converter [5]	27,318	68,027	--	--	--	--	27,318	68,027
Open-hearth furnace	20,419	25,467	138	10	--	--	20,557	25,477
Electric furnace	28,615	904	2,496	41	4,242	434	35,353	1,379
Cupola furnace	1,621	311	286	8	13,345	1,957	15,252	2,276
Air furnace	30	6	27	5	121	46	178	57
Other furnaces [6]	218	220	2	--	465	182	685	402
Total	82,467	94,935	2,949	64	18,173	2,619	103,589	[7] 97,618

[1] Excludes molten pig iron used for ingot molds and direct castings.
[2] Includes only those castings made by companies producing steel ingots.
[3] Excludes companies that produce both steel ingots and steel castings.
[4] Includes consumption in all blast furnaces producing pig iron.
[5] Includes scrap and pig iron processed in metallurgical blast cupolas and used in oxygen converters.
[6] Includes vacuum melting furnaces and miscellaneous melting processes.
[7] Excludes pig iron used in making molds and poured directly into castings.

Table 4.—Proportion of iron and steel scrap and pig iron used in furnaces in the United States

(Percent)

Type of furnace	1973	
	Scrap	Pig iron
Basic oxygen converter	28.7	71.3
Open-hearth furnace	44.7	55.3
Electric furnace	96.2	3.8
Cupola furnace	87.0	13.0
Air furnace	75.7	24.3
Other	63.0	37.0

Table 5.—Iron and steel scrap supply [1] available for consumption in 1973, by State and region

(Thousand short tons)

State and region	Receipts	Production	Total new supply	Shipments [2]	New supply available for consumption
New England:					
Connecticut, New Hampshire, Massachusetts	125	114	239	9	230
Rhode Island and Vermont	123	53	176	2	174
Total	248	167	415	11	404
Middle Atlantic:					
New Jersey	557	138	695	7	688
New York	1,409	2,248	3,657	95	3,562
Pennsylvania	9,192	12,339	21,531	2,010	19,521
Total	11,158	14,725	25,883	2,112	23,771
East North Central:					
Illinois	5,967	5,004	10,971	541	10,430
Indiana	2,970	9,746	12,716	975	11,741
Michigan	6,109	4,925	11,034	182	10,852
Ohio	8,272	10,380	18,652	1,517	17,135
Wisconsin	645	389	1,034	23	1,011
Total	23,963	30,444	54,407	3,238	51,169
West North Central:					
Iowa	541	243	784	1	783
Minnesota	478	68	546	18	528
Missouri	853	290	1,143	8	1,135
Nebraska and Kansas	112	60	172	1	171
Total	1,984	661	2,645	28	2,617
South Atlantic:					
Delaware and Maryland	471	2,505	2,976	141	2,835
Florida and Georgia	695	136	831	2	829
North Carolina	101	21	122	--	122
South Carolina	380	20	400	1	399
Virginia	609	264	873	34	839
West Virginia	1,003	990	1,993	2	1,991
Total	3,259	3,936	7,195	180	7,015
East South Central:					
Alabama	2,056	2,051	4,107	141	3,966
Kentucky	828	954	1,782	176	1,606
Mississippi and Tennessee	786	173	959	17	942
Total	3,670	3,178	6,848	334	6,514
West South Central:					
Arkansas and Louisiana	12	4	16	--	16
Oklahoma	384	65	449	--	449
Texas	2,575	1,639	4,214	99	4,115
Total	2,971	1,708	4,679	99	4,580
Mountain:					
Arizona and Colorado	697	568	1,265	3	1,262
Montana, Nevada, Utah	462	813	1,275	38	1,237
Total	1,159	1,381	2,540	41	2,499
Pacific:					
California	1,894	1,449	3,343	172	3,171
Washington and Oregon	630	152	782	10	772
Total	2,524	1,601	4,125	182	3,943
U.S. total	50,936	57,801	108,737	6,225	102,512

[1] New supply available for consumption is a net figure computed by adding production to receipts and deducting scrap shipped during the year. The plus or minus difference in stock levels at the beginning and end of year is not taken into consideration.

[2] Includes scrap shipped, transferred, or otherwise disposed of during the year.

Table 6.—Consumption of iron and steel scrap and pig iron [1] in 1973, by State and region, by type of manufacturer

(Thousand short tons)

State and region	Steel ingots and castings [2]		Steel castings [3]		Iron foundries and miscellaneous users		Total	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
New England:								
Connecticut, New Hampshire, Massachusetts	69	--	10	--	155	44	234	44
Rhode Island	106	--	--	--	61	3	167	3
Vermont	--	--	--	--	8	4	8	4
Total	175	--	10	--	224	51	409	51
Middle Atlantic:								
New Jersey	224	--	34	1	426	62	684	63
New York	2,573	5,121	134	4	798	64	3,505	5,189
Pennsylvania	18,490	21,456	369	27	814	119	19,673	21,602
Total	21,287	26,577	537	32	2,038	245	23,862	26,854
East North Central:								
Illinois	8,618	7,481	431	2	1,660	390	10,709	7,873
Indiana	11,040	16,823	173	2	867	172	12,080	16,997
Michigan	6,169	7,939	130	1	4,638	658	10,937	8,598
Ohio	14,561	17,346	328	15	2,512	631	17,401	17,992
Wisconsin	--	--	267	1	739	121	1,006	122
Total	40,388	49,589	1,329	21	10,416	1,972	52,133	51,582
West North Central:								
Iowa	--	--	61	--	703	32	764	32
Minnesota	349	--	48	1	139	38	536	39
Missouri	1,035	--	71	--	92	21	1,198	21
Nebraska and Kansas	--	--	131	--	36	2	167	2
Total	1,384	--	311	1	970	93	2,665	94
South Atlantic:								
Delaware	386	--	12	--	--	--	398	--
Florida and Georgia	806	--	--	--	32	8	838	8
Maryland	2,286	5,432	25	--	85	9	2,396	5,441
North Carolina	115	--	--	--	16	8	131	8
South Carolina	341	--	--	--	28	6	369	6
Virginia	262	--	13	--	550	135	825	135
West Virginia	1,915	2,954	37	1	34	14	1,986	2,969
Total	6,111	8,386	87	1	745	180	6,943	8,567
East South Central:								
Alabama	2,205	3,405	216	--	1,476	343	3,897	3,748
Kentucky	1,353	1,908	--	--	302	34	1,655	1,942
Mississippi and Tennessee	355	--	21	1	547	109	923	110
Total	3,913	5,313	237	1	2,325	486	6,475	5,800
West South Central:								
Arkansas and Louisiana	--	--	16	--	--	--	16	--
Oklahoma	337	--	21	--	79	7	437	7
Texas	3,372	1,293	51	1	644	31	4,067	1,325
Total	3,709	1,293	88	1	723	38	4,520	1,332
Mountain:								
Arizona	163	--	98	--	67	--	328	--
Colorado	870	1,026	16	--	68	--	954	1,026
Montana and Nevada	--	--	4	--	82	--	86	--
Utah	871	1,882	4	1	277	16	1,152	1,899
Total	1,904	2,908	122	1	494	16	2,520	2,925
Pacific:								
California	2,863	2,538	129	3	227	59	3,219	2,600
Washington and Oregon	733	--	99	3	11	8	843	11
Total	3,596	2,538	228	6	238	67	4,062	2,611
U.S. total	82,467	96,604	2,949	64	18,173	3,148	103,589	99,816

[1] Includes molten pig iron used for ingot molds and direct castings.
[2] Includes only those castings made by companies producing steel ingots.
[3] Excludes companies that produce both steel ingots and castings.

Table 7.—Yearend consumer stocks of iron and steel scrap, by grade, and pig iron, by State and region

(Thousand short tons)

State and region	Carbon steel (excludes rerolling rails)	Stainless steel	Alloy steel (excludes stainless)	Cast iron (includes borings)	Other grades of scrap	Total scrap stocks	Pig iron stocks
New England:							
Connecticut, New Hampshire, Massachusetts	4	3	1	7	--	15	6
Rhode Island and Vermont	9	--	1	2	--	12	1
Total	13	3	2	9	--	27	7
Middle Atlantic:							
New Jersey	24	--	1	20	--	45	10
New York	236	14	10	115	--	375	86
Pennsylvania	955	50	101	261	4	1,371	252
Total	1,215	64	112	396	4	1,791	348
East North Central:							
Illinois	678	2	7	51	1	739	37
Indiana	546	15	5	402	9	977	70
Michigan	250	14	2	110	7	383	107
Ohio	816	18	41	170	4	1,049	309
Wisconsin	19	--	--	13	1	33	5
Total	2,309	49	55	746	22	3,181	528
West North Central:							
Iowa	44	--	--	21	2	67	5
Minnesota	79	--	--	3	--	82	3
Missouri	105	--	2	8	--	115	6
Nebraska and Kansas	10	--	--	1	--	11	--
Total	238	--	2	33	2	275	14
South Atlantic:							
Delaware and Maryland	169	7	12	38	--	226	17
Florida and Georgia	63	--	--	1	--	64	2
North Carolina	5	--	--	1	--	6	2
South Carolina	50	--	--	--	--	50	3
Virginia	20	--	--	22	--	42	12
West Virginia	35	--	1	4	--	40	9
Total	342	7	13	66	--	428	45
East South Central:							
Alabama	240	--	--	79	1	320	142
Kentucky	66	--	16	19	16	117	12
Mississippi and Tennessee	56	--	--	10	1	67	4
Total	362	--	16	108	18	504	158
West South Central:							
Arkansas and Louisiana	2	--	--	--	--	2	--
Oklahoma	49	--	--	1	--	50	1
Texas	267	--	14	60	3	344	79
Total	318	--	14	61	3	396	80
Mountain:							
Arizona and Colorado	66	--	1	2	5	74	2
Montana, Nevada, Utah	76	--	4	5	12	97	17
Total	142	--	5	7	17	171	19
Pacific:							
California	179	--	3	73	8	263	14
Washington and Oregon	46	1	3	6	--	56	2
Total	225	1	6	79	8	319	16
U.S. total	5,164	124	225	1,505	74	7,092	1,215

Table 8.—Average monthly price and composite price for No. 1 heavy melting scrap in 1973

(Per long ton)

Month	Chicago	Pittsburgh	Philadelphia	Composite price [1]
January	$46.75	$48.00	$50.00	$48.24
February	48.75	48.25	50.25	49.08
March	45.50	48.25	49.50	47.75
April	44.50	49.30	50.90	48.22
May	47.75	51.75	55.50	51.66
June	51.50	53.50	57.50	54.16
July	51.30	53.50	57.50	54.09
August	51.50	55.50	57.75	54.91
September	57.50	58.25	60.75	58.83
October	72.70	67.10	67.30	69.02
November	87.50	81.50	73.50	80.83
December [e]	86.50	76.25	73.00	75.58
Average [e]	57.64	57.59	58.62	57.95

[e] Estimated.
[1] Composite price, Chicago, Pittsburgh, Philadelphia.

Source: Iron Age, Jan. 7, 1974.

Table 9.—U.S. exports and imports for consumption of iron and steel scrap, by class

(Thousand short tons and thousand dollars)

Class	1969		1970		1971		1972		1973	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Exports:										
No. 1 heavy melting scrap	3,452	114,646	3,654	158,483	1,827	64,514	2,289	79,246	3,780	207,743
No. 2 heavy melting scrap	1,009	29,760	1,140	45,516	645	20,297	756	23,200	1,107	52,817
No. 1 baled steel scrap	593	19,679	377	16,290	233	8,460	180	6,112	391	21,565
No. 2 baled steel scrap	1,038	22,038	1,381	41,902	987	22,519	897	19,623	1,221	49,421
Stainless steel scrap	76	22,868	87	30,926	44	12,518	48	11,679	49	16,731
Shredded steel scrap [1]	--	--	1,165	49,344	1,026	36,568	1,463	48,186	2,098	118,133
Borings, shovelings, and turnings	767	13,135	619	15,311	390	8,663	508	10,761	521	16,352
Other steel scrap [2]	1,361	46,930	881	44,423	465	19,030	597	21,562	1,102	57,528
Iron scrap	627	20,481	807	29,715	465	13,851	439	13,026	605	29,721
Total	8,923	289,537	10,111	431,910	6,082	206,420	7,177	233,395	10,874	570,011
Ships, boats, other vessels (for scrapping)	114	2,319	531	11,474	396	6,824	299	9,009	156	8,056
Rerolling material	254	13,170	251	15,464	175	8,978	207	10,213	382	28,489
Grand total	9,291	305,026	10,893	458,848	6,653	222,222	7,683	252,617	11,412	606,556
Imports:										
Iron and steel scrap	311	12,571	279	10,609	263	10,713	295	14,304	337	18,716
Tinplate scrap	24	917	22	591	20	546	17	437	12	384
Total	335	13,488	301	11,200	283	11,259	312	14,741	349	19,100

[1] Separately classified Jan. 1, 1970; formerly part of "Other steel scrap."
[2] Includes terneplate and tinplate.

Table 10.—U.S. exports of iron and steel scrap, by country

(Thousand short tons and thousand dollars)

Country	1969		1970		1971		1972		1973	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	(1)	3	6	370	63	1,757	231	7,857	261	13,840
Belgium-Luxembourg	33	1,844	21	3,563	8	947	5	300	3	535
Brazil	(1)	6	--	--	1	15	61	2,174	5	229
Canada	616	15,286	707	21,525	887	26,204	903	26,605	811	27,097
China, People's Republic of	--	--	--	--	--	--	--	--	428	23,729
France	47	2,868	57	2,785	8	298	(1)	5	30	2,682
Germany, West	93	5,345	45	2,069	13	1,152	7	473	2	283
Greece	--	--	--	--	37	1,228	163	4,893	187	9,429
Hong Kong	1	181	6	652	26	1,023	1	277	1	231
Italy	879	25,781	491	22,657	590	22,599	717	23,222	353	23,966
Japan	4,204	126,254	5,208	208,601	1,744	54,369	2,309	71,309	4,666	234,363
Korea, Republic of	553	20,347	667	30,971	324	11,799	380	13,086	739	42,429
Mexico	580	20,210	821	35,368	555	20,027	587	22,301	1,009	56,063
New Zealand	--	--	7	338	--	--	19	535	42	2,479
Pakistan	(1)	40	(1)	11	52	1,639	[2] 21	[2] 766	1	96
Singapore	--	--	--	--	--	--	25	971	15	1,179
Spain	1,034	29,052	1,154	45,725	610	20,354	721	21,452	1,127	58,197
Sweden	204	19,766	161	24,712	20	4,437	21	4,545	8	2,171
Taiwan	95	3,658	151	7,097	387	12,584	419	14,028	672	39,527
Thailand	61	1,950	45	1,950	39	1,464	85	2,945	139	8,408
Turkey	79	2,013	72	3,530	73	2,465	125	4,571	124	7,212
United Kingdom	310	10,514	251	10,909	335	12,785	25	1,029	142	9,203
Venezuela	58	1,683	179	5,587	212	5,244	284	7,734	76	3,802
Yugoslavia	11	450	22	1,006	56	2,271	--	--	--	--
Other	65	2,286	40	2,484	42	1,759	68	2,317	33	2,861
Total	8,923	289,537	10,111	431,910	6,082	206,420	7,177	233,395	10,874	570,011

[1] Less than ½ unit.
[2] Includes Bangladesh 14,781 short tons ($521,810).

Table 11.—U.S. exports of rerolling material (scrap), by country

(Thousand short tons and thousand dollars)

Country	1969		1970		1971		1972		1973	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Canada	(1)	8	5	208	1	46	2	118	1	34
China, People's Republic of	--	--	--	--	--	--	--	--	7	485
Italy	25	2,220	2	114	1	44	--	--	2	168
Japan	15	588	13	584	5	190	17	789	16	1,209
Korea, Republic of	174	8,318	187	11,737	83	4,562	73	3,491	118	7,014
Mexico	22	1,103	33	2,036	27	1,530	35	1,883	43	2,954
Pakistan	--	--	--	--	--	--	24	1,047	8	422
Spain	--	--	--	--	1	59	5	319	(1)	7
Taiwan	3	156	(1)	10	44	2,023	20	951	149	12,712
Thailand	12	707	6	398	--	--	15	654	28	2,641
Turkey	--	--	--	--	--	--	9	533	4	292
Venezuela	2	65	2	99	2	105	3	200	3	210
Yugoslavia	--	--	--	--	11	419	--	--	--	--
Other	1	5	3	278	--	--	4	228	3	341
Total	254	13,170	251	15,464	175	8,978	207	10,213	382	28,489

[1] Less than ½ unit.

Table 12.—U.S. exports of ships, boats, and other vessels for scrapping

(Thousand short tons and thousand dollars)

Country	1969		1970		1971		1972		1973	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Canada	3	20	18	338	30	493	36	583	2	260
Germany, West	--	--	15	197	5	77	--	--	8	257
Italy	--	--	48	913	--	--	--	--	--	--
Japan	--	--	6	100	--	--	5	74	--	--
Korea, Republic of	--	--	7	169	--	--	--	--	9	370
Mexico	3	51	--	--	--	--	--	--	1	132
Netherlands	--	--	15	275	--	--	--	--	(1)	40
Spain	70	1,098	357	7,637	255	4,788	146	3,907	22	1,002
Taiwan	20	849	58	1,607	106	1,463	112	4,445	114	5,994
Other	18	301	7	238	(1)	3	--	--	(1)	1
Total	114	2,319	531	11,474	396	6,824	299	9,009	156	8,056

[1] Less than ½ unit.

Table 13.—U.S. imports for consumption of iron and steel scrap, by country

Country	1972		1973	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Argentina	--	--	176	$6
Australia	18	$8	18	1
Canada	288,509	12,308	336,119	17,696
Dominican Republic	16	3	83	6
French West Indies	1,296	43	--	--
Germany, West	1,611	278	55	46
Haiti	--	--	785	9
Jamaica	1,009	33	1,686	73
Japan	135	65	19	1
Liberia	--	--	650	21
Mexico	14,015	318	6,606	151
Netherlands	441	338	816	323
South Africa, Republic of	45	26	--	--
Sweden	1,209	123	139	49
United Kingdom	3,437	1,139	1,365	713
Other	299	59	116	5
Total	312,040	14,741	348,633	19,100

Iron Oxide Pigments

By Henry E. Stipp [1]

Iron oxide pigments were in short supply during 1973 despite record high domestic production and increased imports, mainly of synthetic iron oxide pigments. Domestic demand for iron oxide pigments increased susbstantially because of a high level of paint, varnish, and lacquer sales for use mainly in the housing, automobile, and durable goods industries. Iron oxide pigments also were used for preparing materials for magnetic applications. Increased foreign demand for iron oxide pigments, as a result of a worldwide economic expansion, reduced the quantity of iron oxide material that normally could have been imported into the United States. Although U.S. imports of synthetic iron oxide pigments were larger than those in 1972, they were insufficient for domestic demand, and together with low inventories incurred in previous years, limited the ability of suppliers to satisfy total domestic requirements. However, the outlook for sluggish economic activity in 1974, particularly in the construction and automobile industries, should give producers an opportunity to catch up with domestic iron oxide pigment demand.

Legislation and Government Programs.—The U.S. Department of the Treasury issued a ruling that permanent magnets of ceramic material (ferrites) and alnico from Japan were not being sold in the United States at less than fair value.[2] In 1972, Japanese magnets totaling $3.3 million were imported into the United States.

Table 1.—Salient iron oxide pigments statistics in the United States

	1969	1970	1971	1972	1973
Mine production short tons	40,600	38,600	W	W	W
Crude pigments sold or used do	40,800	39,200	W	W	W
Value thousands	$362	$442	$415	$418	$770
Finished pigments sold short tons	142,900	124,000	128,300	r 174,392	178,788
Value thousands	$32,000	$28,000	r $31,000	r $40,330	$46,158
Exports short tons	4,000	5,000	4,000	4,000	10,000
Value thousands	$1,000	$2,000	$2,000	$2,000	$3,000
Imports for consumption short tons	33,000	33,000	36,000	47,000	51,000
Value thousands	$5,000	$6,000	$6,000	$9,000	$12,000

r Revised. W Withheld to avoid disclosing individual company confidential data.

DOMESTIC PRODUCTION

Finished iron oxide pigments production (as indicated by sales) in 1973 increased, for the third consecutive year, to 178,788 short tons, a 2.5% rise over the 174,392 short tons of 1972. Some increase in plant capacity and more efficient operation of existing plants were considered to be the principal factors involved in producers' ability to raise domestic output. Yellow iron oxide production in 1973 posted the largest percentage increase (8.6%) in the manufactured category; natural metallic brown iron oxide increased 7.3% in output. Production of manufactured pure red iron oxide by other chemical processes increased 19.9% over that of 1972, whereas production of pure red iron oxide from calcined copperas decreased 16.3% from that of 1972. Output of natural red iron oxide in 1973 decreased 9.1% from that of 1972.

[1] Physical scientist, Division of Ferrous Metals—Mineral Supply.

[2] Wall Street Journal. U.S. Finds No Dumping of Japanese Magnets. V. 181, No. 55, Mar. 21, 1973, p. 30.

The total value of finished iron oxide pigments increased 14.6% in 1973 to $46.2 million, compared with $40.3 million in 1972. In 1973, 14 companies operated 19 plants in 10 States. Pfizer Inc. was the major producer of finished iron oxides with plants in California, Illinois, and Pennsylvania.

Crude iron oxide pigment production and value increased sharply over that of 1972. Figures on production of crude pigments were withheld to avoid disclosing confidential company data. In 1973 crude iron oxide pigments shipments were valued at $770,000, an 84% increase over the $418,000 value in 1972. Six companies operating mines or plants in six States reported production of crude iron oxide pigments in 1973. The Cleveland-Cliffs Iron Co. produced the largest quantity from mines in Michigan.

CONSUMPTION AND USES

Apparent domestic consumption of iron oxide pigments[3] increased 1.2% to 220,083 short tons in 1973, compared with 217,395 short tons in 1972. Consumption probably was curtailed by supply shortages of several types of iron oxide pigments that occurred throughout the year. Reportedly, red and yellow manufactured iron oxide pigments were scarce. One of the factors said to be responsible for shortages of manufactured iron oxide pigments was lack of plant capacity. Capital investment was not attracitve during the previous 5 years because of the low price for iron oxide pigments. Thus there was little incentive for constructing new plants and installing new equipment. The added investment required for pollution control also was reported as contributing to the lack of capacity.[4]

Another factor contributing to domestic shortages was reportedly the devaluation of the U.S. dollar. This made it possible for foreign consumers to offer attractive prices for U.S. products. Exports of iron oxide pigments in 1973 were more than double those of 1972. Iron oxide pigments were used in paints, rubber, plastics, concrete products, paper, magnetic ink, fertilizers, and animal food. They were used also in preparing ferrities for applications as television components, filters in radio equipment, computer memory cores, door latches and seals, small electric motors, and inductor and microwave devices. Iron oxide was used in miscellaneous applications such as abrasives, welding rod coatings, soil conditioners, foundary sands, and automobile brake linings. Iron oxides combined with aluminum in paint formulations produce paints described as metallic for use in protecting automobiles from corrosion and enhancing their beauty. It was estimated that in 1972 the automobile industry used about $200 million worth of paint products in producing about 10 million vehicles.

Data are not collected by the Bureau of Mines on specific uses for iron oxide pigments, and the figures given in table 2 do not necessarily reflect all sales of iron oxide pigment material for uses other than pigments.

[3] Indicated by quantity of finished iron oxide pigments sold plus imports of natural and synthetic iron oxide pigments minus exports of pigment-grade iron oxides and hydroxides.

[4] American Paint Journal. Coatings Update. V. 59, No. 30, Jan. 7, 1974, p. 66.

Table 2.—Finished iron oxide pigments sold by processors in the United States by kind

Pigment	1972 Quantity (short tons)	1972 Value (thousands)	1973 Quantity (short tons)	1973 Value (thousands)
Natural:				
Brown:				
Iron oxide (metallic) [1]	19,074	$3,467	20,466	$3,448
Umbers:				
Burnt	5,376	1,441	5,914	1,685
Raw	1,541	435	1,550	456
Red:				
Iron oxide [2]	35,541	2,547	33,324	2,682
Sienna, burnt	1,201	531	541	271
Yellow:				
Ocher [3]	6,223	495	6,085	474
Sienna, raw	992	389	1,330	419
Total natural	69,948	9,305	69,210	9,435
Manufactured:				
Black: Magnetic	3,149	1,376	2,458	1,210
Brown: Iron oxide	6,539	2,748	7,728	3,413
Red:				
Pure red iron oxides:				
Calcined copperas	19,185	6,499	16,059	6,067
Other chemical processes	14,426	4,531	[4] 17,300	[4] 6,002
Venetian red	505	135	175	46
Yellow: Iron oxide	31,867	11,118	34,605	13,389
Total manufactured	75,671	26,407	78,325	30,127
Unspecified including mixtures of natural and manufactured red iron oxides	28,773	4,618	31,253	6,596
Grand total	174,392	40,330	178,788	46,158

[1] Includes black magnetite and vandyke brown.
[2] Includes pyrite cinder.
[3] Includes yellow iron oxide.
[4] Includes other manufactured red iron oxide.

PRICES

Most synthetic grades of iron oxide pigments experienced price increases ranging from 1 cent to 1½ cents per pound effective from May 7 to May 11. Synthetic red iron oxides advanced from ½ cent to 2 cents per pound. Synthetic brown increased 1 cent per pound. Most synthetic yellow iron oxide was increased from 1 to 1½ cents per pound; light lemon advanced 2½ cents per pound.

Table 3.—Prices quoted on finished iron oxide pigments, per pound, in bags, unless otherwise noted, as of December 31, 1973 [1]

Pigment	Low	High	Pigment	Low	High
Black:			Red:		
Pure	$0.1875	0.2050	Domestic primers	$0.0775	0.1150
Synthetic	.1788	.2050	Persian Gulf [2]	.1400	--
Brown:			Pure synthetic	.1825	.1925
Metallic	.0900	.1125	Spanish, exdock, N.Y. [2]	.1100	.1275
Pure, synthetic	.2025	.2350	Yellow:		
Sienna, American, burnt	.1500	.2850	Ocher, domestic	.0540	.0650
Sienna, American, raw	.1450	.2375	Ocher, French-type	.0975	.1300
Umber, American, burnt	.1225	.1550	Pure, light lemon	.1700	.1950
Umber, American, raw	.1250	.1475	Other shades	.1700	.1850
Vandyke, imported [2]	--	.4750			
Vandyke, American [2]	.1550	.1750			

[1] Low and high range covers prices for carlots and less than carlots, at the works.
[2] Barrels.

Sources: Chemical Marketing Reporter and American Paint Journal.

FOREIGN TRADE

The quantity of natural and manufactured iron oxide pigments imported into the United States for consumption in 1973 increased 8.3% to 51,183 short tons, compared with 47,271 short tons in 1972. The value of iron oxide pigments imported in 1973 increased 40.8% to $12 million compared with $8.5 million in 1972. Manufactured (synthetic) iron oxide pigments comprised 73% of total imports of iron oxide materials in 1973. Approximately 70.3% of the natural iron oxide pigments imported in 1973 consisted of crude and refined umber.

The major share of synthetic iron oxide pigments imported in 1973 came from West Germany, Canada, and the United Kingdom. Synthetic imports from Canada increased 32% in quantity and 48% in value compared with those of 1972. Imports of synthetic material from West Germany and the United Kingdom decreased 5% and 42%, respectively, in quantity compared with imports in 1972. Natural iron oxides imported from Spain decreased 42% in quantity, whereas those imported from West Germany increased substantially. Imports of Persian Gulf red iron oxide ceased in 1973, reportedly because of a 300% increase in price, which placed its delivered U.S. price near that of comparable synthetic oxides.

A large West German producer began operating major new facilities for producing iron oxide pigments in 1973. Reportedly, large quantities were slated to be shipped to the United States; however, allocations were not increased owing to a high level of back orders.[5]

The quantity of pigment-grade iron oxide and hydroxides exported from the United States in 1973 increased 132% to 9,888 short tons, compared with exports of 4,268 short tons in 1972. Canada received the major share of U.S. exports. The value of pigment-grade iron oxide and hydroxides exported in 1973 increased 61% to $3.101 million, compared with $1.926 million in 1972.

[5] American Paint Journal. The Markets. V. 58, No. 26, Dec. 10, 1973, p. 36.

Table 4.—U.S. imports for consumption of selected iron oxide pigments

Kinds	1972		1973	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Natural:				
Ocher, crude and refined	93	$6	66	$9
Siennas, crude and refined	1,272	196	1,192	205
Umber, crude and refined	8,234	412	9,665	569
Vandyke brown	621	77	966	144
Other [1]	2,777	236	1,858	378
Total	12,997	927	13,747	1,305
Manufactured (synthetic)	34,274	7,602	37,436	10,700
Grand total	47,271	8,529	51,183	12,005

[1] Classified by the Bureau of the Census as "Natural iron oxide and iron hydroxide pigments, n.s.p.f."

Table 5.—U.S. imports for consumption of iron oxide and iron hydroxide pigments, n.s.p.f., by country

Country	Natural				Synthetic			
	1972		1973		1972		1973	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Austria	15	$2	30	$8	--	--	--	--
Belgium-Luxembourg	--	--	--	--	19	$9	20	$2
Canada	--	--	1	3	11,782	1,744	15,506	2,574
Ecuador	--	--	--	--	--	--	18	5
Finland	--	--	--	--	--	--	60	26
France	149	17	56	9	23	12	--	--
Germany, West	3	5	387	201	19,751	5,028	18,782	6,633
Iran	254	9	--	--	--	--	25	7
Italy	--	--	2	5	--	--	--	--
Japan	--	--	1	(1)	121	272	945	911
Mexico	--	--	--	--	5	1	447	112
Netherlands	--	--	--	--	137	88	243	127
South Africa, Republic of	--	--	--	--	20	2	--	--
Spain	2,234	168	1,304	119	--	--	--	--
Sweden	40	7	17	5	--	--	--	--
Switzerland	--	--	1	4	--	--	--	--
United Kingdom	82	28	59	24	2,416	446	1,390	303
Total	2,777	236	1,858	378	34,274	7,602	37,436	10,700

[1] Less than ½ unit.

Table 6.—U.S. exports of iron oxide and hydroxides in 1973, by country

Destination	Pigment grade		Other grades	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Argentina	15	$15	--	--
Australia	307	198	70	$88
Belgium-Luxembourg	62	28	38	18
Brazil	806	302	90	83
Canada	6,096	1,152	993	503
Colombia	21	11	24	14
Ecuador	114	83	4	2
Finland	28	12	--	--
France	189	149	172	116
Germany, West	75	116	182	146
Ghana	22	10	--	--
Guatemala	12	6	4	2
Hong Kong	13	10	--	--
India	3	1	34	38
Indonesia	--	--	49	8
Iran	20	14	5	21
Italy	175	92	527	597
Japan	262	103	806	748
Korea, Republic of	33	17	--	--
Mexico	111	110	6	6
Netherlands	7	5	424	345
Netherlands Antilles	4	2	1	1
New Zealand	91	29	--	--
Panama	16	6	5	3
Peru	25	10	17	8
Philippines	94	31	10	5
Saudi Arabia	1	(1)	54	54
South Africa, Republic of	21	22	10	9
Spain	19	10	27	10
Sweden	15	8	11	8
United Kingdom	797	344	803	693
Venezuela	216	86	47	32
Vietnam, South	101	57	9	4
Other	117	62	53	39
Total	9,888	3,101	4,475	3,601

[1] Less than ½ unit.

TECHNOLOGY

Several new technological processes that produce iron oxide as a byproduct of their main operations have been reported. These processes could furnish crude iron oxide material for further refinement by producers to finished iron oxide pigments. One of these is a chemical process that removes sulfur from coal before it is burned and also produces iron oxide and iron sulfate in salable product form.[6]

The removal of impurities from water can be accomplished by seeding the effluent with iron oxide particles and treating the resulting solution with a high gradient magnetic separation machine.[7] Also weakly magnetic iron oxide and other minerals can be recovered, using the high gradient magnetic separation device.

A new high-intensity wet magnetic separator that can be used to remove iron oxides from ground fuel ash and quenched blast furnace flue gases has been introduced in England.[8]

Ilmenite ore was leached with ferric chloride solution; the resulting liquor was oxygenated to obtain a titanium dioxide concentrate and a substantially pure iron oxide byproduct.[9]

Titanium and iron oxides were prepared from red mud obtained as a byproduct of a process to produce alumina from bauxite.[10]

A lithim oxide—iron oxide—silicon dioxide ferrite material was studied to determine regions where $LiFe_5O_8$ could be formed as a crystalline phase.[11] The material was investigated also to determine how magnetic, electrical, and physical properties were related to composition, heat-treatment time, and temperature. Saturation magnetization, remanence, coercivity, and alternating current resistivities data were reported. The dielectric properties gave large dispersion effects. A limited substitution of silicon into the $LiFe_5O_8$ structure was indicated.

A possible successor to ferrite-core computer memory devices was reported with the discovery of a cheaper and easier method to make bubble memories for computer information storage systems.[12] Bubble memories have the capacity to store very much more data in less space and to function much more rapidly and reliably than mechanical and ferrite core devices. In addition, bubble memories are less costly to produce than ferrite-core memories. However, until bubble memory devices are perfected and gain acceptance by computer producers, ferrite materials will continue to be used in computers for information storage.

In March, the commercial production of samarium-cobalt magnets signaled the loss of a part of the market for ferrite permanent magnets.[13] The samarium-cobalt magnets are about three to four times stronger than most other permanent magnets; however, ferrite magnets will continue to be used in those applications, where cost is a factor. Ferrite magnets are significantly less costly to produce than samarium-cobalt magnets. The new magnets will be used in applications where size and field strength are the main factors to be considered.

A steam and heat treatment process applied to iron powder increased the corrosion resistance of the powder because of a film of oxide deposited on the exposed surface of the iron particles.[14] The iron oxide also improves the breaking-in condition of the part, and oxide in the pores space gives a network of hard, wear-resistant material after the surface film wears away. The treatment also imparts an attractive blue-black color to the iron particle and possibly could be used for pigment purposes.

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[6] Journal of Mines, Metals and Fuels. Chemical Process for Desulphurisation of Coal. V. 20, No. 11, November 1972, p. 351.

[7] Chemical and Engineering News. Magnetic Methods Treat Ores, Coal, Water. V. 51, No. 19, May 7, 1973, pp. 17–18.

[8] Work cited in footnote 7.

[9] Lynd, L. E., and O. Moklebust (assigned to NL Industries, Inc.). Leaching of Ilmenite To Obtain a High-Quality Iron Oxide Byproduct. U.S. Pat. 3,719,468, Mar. 6, 1973, 5 pp.

[10] Lightbourne, R. C., and H. B. Baetz. Extraction of Anhydrous Chlorides of Titanium and Iron From Red Mud Obtained in the Production of Alumina From Bauxite. Brit. Pat. 1,304,345, Jan. 24, 1973, 9 pp.

[11] Weaver, E. A., and M. B. Field. Magnetic, Electrical, and Physical Properties of Li_2O-Fe_2O_3-SiO_2 compositions. Am. Ceram. Soc. Bull., v. 52, No. 5, May 1973, pp. 467–472.

[12] Business Week. Why IBM Got a Jump in Bubble Memories. No. 2267, Feb. 17, 1973, pp. 38–40.

[13] American Metal Market. Hitachi Magnetics Starts Samarium Cobalt Production. V. 80, No. 122, June 22, 1973, p. 7.

[14] American Metal Market. Heat Treating: Important Step in G. M. Powder Metallurgy. V. 80, No. 126, June 28, 1973, p. 11.

Kyanite and Related Materials

By J. Robert Wells [1]

Kyanite, andalusite, and sillimanite are anhydrous aluminum silicate minerals that are alike in both composition and use patterns and have the same chemical formula, $Al_2O_3 \cdot SiO_2$. Related materials include synthetic mullite, dumortierite, and topaz, also classified as aluminum silicates, although the last two additionally contain substantial proportions of boron and fluorine, respectively. All of these kyanite-group substances have the capability of serving as raw materials for manufacturing special-duty refractories in the high-alumina caetgory, but there has been no record in recent years of significant utilization of either dumortierite or topaz for this purpose in the United States.

Although published statistics are not sufficiently complete to be wholly conclusive, it appears that the United States, India, and the Republic of South Africa are the leading world producers of kyanite-group minerals and that they may not be far from evenly matched in this regard. It can be presumed that the U.S.S.R. and perhaps a few other industrialized nations also produce significant quantities of these materials.

Consumption of the more sophisticated refractories, after a 2-year decline that occasioned a small decrease in domestic kyanite production (1972) and substantial curtailments abroad (1971 and 1972), recovered notably in 1973, pushing U.S. demand for kyanite-group materials to a level reportedly as much as 15% above the available supply. The conspicuous fact that U.S. exports of these materials increased 27% in 1973 over those of 1972 was evidence, furthermore, that they were being eagerly sought by the rest of the world. In August 1973, reflecting the kyanite seller's-market situation, one of the two major U.S. producers, C–E Minerals Inc., announced the launching of an immediate 30,000-ton-per-year expansion of its kyanite mining and processing facilities in Georgia.

Although no curtailment of operations explicitly attributable to fuel shortages had been reported by kyanite producers through yearend 1973 there may have been a portent in one firm's magazine advertisement that included an appeal to customers for tolerance because of "problems and delays from our many suppliers."

Legislation and Government Programs.—The allowable depletion rates for kyanite, established by the Tax Reform Act of 1969 and unchanged through 1973, were 22% for domestic production and 14% for foreign operations.

Revision in 1970 of the list of strategic materials for stockpiling excluded kyanite-mullite, and Congress accordingly authorized a sealed-bid sale of the Government holdings (2,816 tons of Indian lump kyanite and 2,004 tons of fused synthetic mullite). The entire quantity of mullite was sold in June 1973 for $160,320; the stockpiled kyanite, for which no bids had been received through December 1973, was scheduled to be re-offered at a future date.

The U.S. Geological Survey's Office of Minerals Exploration provides Government loans of up to 50% of approved costs for the exploration of eligible kyanite deposits; no loans for that purpose were made in 1973.

[1] Physical scientist, Division of Nonmetallic Minerals—Mineral Supply.

DOMESTIC PRODUCTION

Production of kyanite in the United States increased notably in 1973, surpassing the previous record (1971) by 10% in tonnage and by 11% in terms of total value thus reaching the highest point in history. All but a small fraction of the domestic kyanite produced in 1973 came from three hard-rock openpit operations in two eastern States. Kyanite Mining Corp. used a froth-flotation process to extract the mineral from kyanite-quartzite ore mined at two locations in Virginia—Willis Mountain in Buckingham County and Baker Mountain in Prince Edward County; in Georgia, C–E

Minerals, Inc., treated the same type of ore in a similar operation at Graves Mountain, Lincoln County. The comparatively small remainder of the 1973 total in the form of kyanite-sillimanite concentrate was obtained by E. I. du Pont de Nemours & Co., Inc. as a byproduct from the recovery of titanium and zirconium minerals from a sand deposit at Trail Ridge, Clay County, Fla.

Synthetic mullite was produced in 1973 at six locations in the eastern United States, and although higher total values were reported for some previous years, the 1973 tonnage was the highest on record. Electric-furnace fused mullite was produced by Babcock & Wilcox Co. at Augusta, Richmond County, Ga. High-temperature sintered material was produced by A. P. Green Refractories Co. at Philadelphia, Pa.; Harbison-Walker Refractories Co. at Eufala, Henry County, Ala.; Mullite Corp. of America at Amercius, Sumter County, Ga.; Chas. Taylor Sons Co. at Taylor, Greenup County, Ky.; and H. K. Porter Co., Inc. at Shelton, Fairfield County, Conn. Operation of the H. K. Porter plant in Connecticut was terminated in May 1973, the property was sold, and it was reported that resumption of mullite production at that location is not expected.

Table 1.—Synthetic mullite production in the United States

(Short tons and thousand dollars)

Year	Quantity	Value
1969	48,588	6,847
1970	55,516	8,840
1971	55,077	4,945
1972	46,389	4,080
1973	58,176	5,211

CONSUMPTION AND USES

Kyanite and related materials, conforming to the established end-use pattern, were consumed in 1973 mostly in the manufacture of high-alumina or mullite class refractories and in lesser quantities as ingredients in some ceramic compositions. Imported Indian kyanite was calcined in its natural lump form, after which it was usually separated into designated particle-size ranges for use chiefly as a grog. Domestic kyanite, already ground to minus 35 mesh as required by the flotation process used in its separation and recovery, was marketed in the raw form or after heat treatment, that is, as mullite, which was sometimes further reduced in particle size before use. In the 35- to 48-mesh range, the mineral was used mostly in refractories applications such as for high-temperature mortars or cements, ramming mixes, and castable refractories, or with clays and other ingredients in refractory compositions for making kiln furniture, insulating brick, firebrick, and a wide variety of other refractory articles. More finely ground material, minus 200 mesh for example, was used in body mixes for sanitary porcelains, wall tile, precision casting molds, and miscellaneous special-purpose ceramics.

PRICES

Engineering and Mining Journal, December 1973, listed prices for kyanite, f.o.b. Georgia, ranging from $58 to $73 per short ton in bags and $2 less per ton for bulk shipments.

Prices ranges quoted for kyanite-group materials in Ceramic Industry Magazine, January 1974, were as follows:

	Per short ton
Andalusite	$30–$60
Kyanite	63–116
Mullite, calcined	82–135
Mullite, fused	160–450

The December 1973 issue of Industrial Minerals (London), quoted kyanite-group price ranges approximately equivalent (with some uncertainty due to a floating exchange rate) to the following:

	Per short ton
Andalusite, Transvaal, c.i.f. main European port	$45–$54
Kyanite, Indian, c.i.f. main European port	64– 83
Sillimanite, Indian, natural bagged, f.o.b.	73– 79
Sillimanite, Indian, calcined, f.o.b. Calcutta	83– 90

FOREIGN TRADE

For many years U.S. kyanite-group foreign trade could be presented by plotting the annual export and import statistics to the same scale, but the two sets of data have become so increasingly disparate in recent years, that such a graphic comparison is now of little value. Exports, formerly in a subordinate position, have registered a spectacular increase, while imports have fallen almost to the point of disappearance. The export/import tonnage ratio, which had averaged on the low side of 1 to 1 since records were first kept, decisively crossed over that line in 1963, and the reported figures are no longer of comparable magnitude; in both 1972 and 1973 exports were hundreds of times greater than imports. It was stated that only about 15% of the domestic kyanite output is shipped abroad,[2] so that it can be supposed that the greater part of the material currently being exported consists of mullite. It is to be noted, however, that some element of uncertainty is inherent in such conclusions because the Bureau of the Census export figures on which they are based do not clearly distinguish synthetic mullite from some other mullite-containing materials prepared by high-temperature processing of certain bauxitic and kaolinitic minerals.

[2] Johnson, T.W. Kyanite and Related Minerals. Min. Eng., v. 25, No. 1, January 1973, pp. 38–39.

Table 2.—U.S. exports and imports for consumption of kyanite and related minerals

	1971		1972		1973	
	Quantity (short tons)	Value	Quantity (short tons)	Value	Quantity (short tons)	Value
Exports:						
Argentina	257	$20,404	112	$7,797	257	$21,279
Australia	565	45,434	357	26,468	7,145	266,817
Belgium-Luxembourg	221	18,658	2,177	140,756	1,452	276,476
Brazil	58	5,118	124	33,119	3,965	181,819
Canada	5,698	412,310	5,708	419,689	6,010	423,327
Colombia	661	37,791	312	19,399	89	5,547
Denmark	--	--	1,094	96,133	912	62,664
France	717	80,584	492	56,116	803	102,263
Germany, West	1,502	92,571	18,292	840,785	49,081	2,489,435
Italy	9,961	533,850	8,477	435,069	4,859	372,819
Japan	2,166	180,319	25,338	1,035,628	2,783	220,297
Mexico	1,877	128,057	1,775	118,482	2,731	192,239
Netherlands	2,635	187,840	6,561	262,610	6,449	405,806
New Zealand	42	3,087	--	--	369	34,697
Philippines	170	17,635	189	19,359	271	32,117
South Africa, Republic of	157	8,230	17	1,083	3,909	251,574
Sweden	2,609	163,405	731	42,542	811	56,761
United Kingdom	1,461	103,652	1,446	107,996	826	64,088
Venezuela	583	41,597	558	52,485	949	86,080
Other	214	16,725	151	21,545	43	5,788
Total	31,554	2,097,267	73,911	3,737,061	93,714	5,551,893
Imports:						
France	1	1,612	--	--	2	926
India	1,301	60,743	124	5,773	177	9,080
South Africa, Republic of	41	2,891	--	--	42	3,213
Total	1,343	65,246	124	5,773	221	13,219

WORLD REVIEW

France.—Although at present France is a substantial net importer of kyanite-group minerals for making high-alumina refractories, it was predicted that increased production of andalusite from the relatively new mining operation of Denain-Anzin Minéraux at Glomel will be capable of meeting a major part of the nation's future requirements of those materials.[3]

Guyana.—The Guyanan Geological Society, in a program aimed at diversification of the domestic mining industry, launched a study of recorded occurrences of a number of minerals not presently being exploited. It was stated that a known deposit of kyanite was determined to contain 2.2 million tons of ore, presumably of workable grade. Successful commercialization of this mineral, providing an advantageous

[3] Industrial Minerals (London). Refractories in Western Europe. No. 65, February 1973, pp. 9–11, 13–15, 17–19, 21, 23, 25, 27.

complement for the already established bauxite industry, would help to bring Guyana into a favorable position as a world supplier of high-alumina raw materials for the manufacture of refractories.[4]

India.—Lump kyanite from India has long had an international reputation for superiority as a raw material able to serve in a number of exacting applications. Although that mineral has been a significant item in India's export trade for nearly 50 years, there have been until recently no reliable estimates of available reserves in even the best-known deposits. To remedy that deficiency, the Geological Survey of India launched a study in 1970 aimed at a definitive evaluation of those resources; a preliminary report issued in 1971 pointed to the existence in the States of Bihar, Maharashtra, Mysore, and Orissa of 3.8 million tons of recoverable kyanite ore. The average grade of the material was not specified, but pure kyanite, $Al_2O_3 \cdot SiO_2$, theoretically contains 62.9% alumina, and material produced in the named areas in the past has been predominantly in the range from 60% to 62% Al_2O_3. The Survey also identified, in addition to the presumably high-grade mineral referred to, approximately 67 million tons of kyanite-quartzite material in Bihar probably rating a classification of subeconomic under present circumstances. India's kyanite production was in private hands until March 10, 1972, when the Indian Central Government nationalized the holdings of the then principal producer, the Indian Copper Corp., owner of the famous Lapsa Buru alluvial deposits, said to hold at least nine-tenths of the nation's kyanite reserves. Compounding the uncertainty of the situation, it was announced early in 1973 that the State Government of Bihar has decided "in principle" to take over all kyanite mining operations in that State.

Japan.—High-alumina raw materials for making refractories are not available in sufficient quantities from indigenous sources, and the nation's requirements must be imported; India, the Republic of South Africa, and the United States are the principal suppliers. Imports of kyanite, andalusite, and sillimanite amounted to 43,100 tons in 1970, 28,800 tons in 1971, and about 23,700 tons in 1972 with exports averaging about 4,000 tons annually.[5] Total figures for Japanese consumption of kyanite-group minerals plus synthetic mullite in those same 3 years were 90,200 tons, 48,700 tons, and 51,700 tons, respectively.[6]

South Africa, Republic of.—South Africa's output of andalusite in 1972 (latest figure available) amounted to 50,500 tons, 3% more than the figure for the previous year. Production of sillimanite, on the contrary, dropped sharply in 1972, reaching only 10,500 tons, 46% less than the 1971 total and 73% below that for 1970, apparently reflecting falling demand for export, the customary outlet for about 90% of the yearly total. In comparison, only 30% to 50% of the andalusite produced in South Africa is shipped to foreign markets.[7]

Tanzania.—Kyanite, in association with at least four other nonmetallic minerals of actual or potential commercial importance, was found to exist in Tanzania's residual beach sands along the Indian Ocean coastline. A report by the Tanzanian State Mining Corp. pointed out that, although a conclusive survey of the Continental Shelf is not yet available, it is inferrable that extensive marine deposits of those minerals will be found at dredgeable depths at a number of offshore locations.

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[4] Industrial Minerals (London). Guyana: Government to Make Most of Kyanite and Kaolin. No. 72, September 1973, pp. 31–32.

[5] Industrial Minerals (London). Refractories in Japan. No. 67, April 1973, pp. 9, 11, 13, 15, 17–19.

[6] Industrial Minerals (London). Japan: Refractory Raw Materials. No. 69, June 1973, pp. 37–38.

[7] Industrial Minerals (London). South Africa: Mineral Production in 1972. No. 68, May 1973, p. 29.

Institute of Geological Sciences, Mineral Resources Division. Statistical Summary of the Mineral Industry—World Production, Exports and Imports 1967–1971. Her Majesty's Stationery Office (London), 1973, pp. 337–338.

Table 3.—Kyanite, sillimanite and related materials: World production by country [1]

(Short tons)

Country and commodity [2]	1971	1972	1973 p
Australia: Sillimanite [3]	945	633	e 660
India:			
Kyanite	69,977	75,485	e 77,000
Sillimanite	4,769	4,490	e 4,500
Korea, Republic of (South): Andalusite	82	35	e 30
Spain: Andalusite	6,449	6,614	e 6,600
South Africa, Republic of:			
Andalusite	49,021	50,549	e 68,000
Sillimanite	19,246	10,445	e 22,000
United States:			
Kyanite	W	W	W
Synethetic mullite	55,077	46,389	58,176

e Estimate. p Preliminary. W Withheld to avoid disclosing individual company confidential data.

1 Owing to incomplete reporting, this table has not been totaled.

2 In addition to the countries listed, a number of other countries presumably produce kyanite and related minerals, but output data are not reported and no basis is available for estimation of output levels.

3 In addition, sillimanite clay (also called kaolinized sillimanite) is produced; output in 1971 totaled 11,229 short tons. (Data for 1972 and 1973 not available.)

TECHNOLOGY

Refractories, both those of the fire clay type and those based on such nonclay materials as mullite, are indispensably involved in all ramifications of today's complex industrial structure and thus exert a pervasive influence upon practically every aspect of modern living. Availability of suitable furnace refractories, for example, is a vital prerequisite for the generation of steam power and for the smelting and refining of copper for which there is no acceptable substitute in the generation of electricity. A report was published pointing out that an inadequate allocation of energy to the refractories industry would inevitably precipitate profound changes in the established technology of refractories production and utilization, seriously hampering the general economy and, in a synergistic repercussion, contributing to an even further restriction of the energy supply itself.[8]

In a patented procedure for beneficiation of kyanite and other specified silicate ores in which iron is subordinate but not absent, undesirable overgrinding is minimized by first pre-crushing the material and then heating it in air to a temperature in the range of 1,100° C to 1,400° C. The calcination is said to have an agglomerating effect on the siderite, goethite, or other iron minerals present, and it is claimed that the proportion of fines generated in the subsequent reduction of the ore to the desired particle size is substantially less than when the same material is comparably ground in an uncalcined condition.[9]

A patent was issued for producing glass-ceramic compositions in the Cs_2O-Al_2O_3-SiO_2 system, in which the principal crystalline phase consists essentially of mullite. Such materials are described as translucent to transparent and dimensionally stable at temperatures up to 1,250° C, which properties enable them to serve advantageously for high-temperature lamp envelopes.[10]

A journal article dealing especially with the high-alumina refractory materials, of which kyanite, andalusite, sillimanite, and mullite are examples, contained a discussion of various criteria other than chemical analysis that should be taken into consideration in selecting refractories for specific applications. Hot modulus of rupture, room-temperature modulus of rupture, fracture toughness, and deformation at high temperature were among the properties mentioned. Examples were cited in support of the conclusion that chemical composition alone should be regarded as no more than a partial guide to a refractory's performance.[11]

8 Barr, Harry W., Jr., Ronald F. Ayers, W. Halder Fisher, Winston H. Duckworth, and Larry G. McCoy. Summary Report on a Study of the Refractories Industry—Its Relationship to the U.S. Economy and Its Energy Needs (to the Refractories Institute). Battelle Memorial Institute, Columbus, Ohio, Oct. 5, 1973, 127 pp.

9 Lee, T. E., and F. W. Frey (assigned to Ethyl Corp.). Method of Improving the Grindability of Alumina-Silicate Ores. U.S. Pat. 3,730,445, May 1, 1973.

10 Beall, George H., and Hermann L. Rittler (assigned to Corning Glass Works). U.S. Pat. 3,726,695, Apr. 10, 1973.

11 Friedrichs, James R. Don't Buy Alumina Content. Iron and Steel Eng., v. 50, No. 11, November 1973, pp. 40–42.

Although mullite-based ceramics offer a number of advantages (notably superior mechanical stability and resistance to thermal shock), development of such products has been hampered by inadequacies, both qualitative and quantitative, in the available supply of requisite constituents. Preparation of appropriate ceramic powders of suitable purity by organo-metallic and freeze-dry techniques is costly, tedious, and often hazardous due to the use of volatile solvents that may be both flammable and toxic. Direct mixtures of alpha-alumina and silica do not react readily to form mullite, while those of amorphous alumina and silica, although highly reactive, generally produce mullite with an unacceptable proportion of residual corundum. In the course of research directed toward the processing of aluminosilicate ceramics, an improved method was developed for preparing mullite powder. A weakly acidified colloidal suspension of gamma-alumina was mixed with similarly dispersed amorphous silica, and the resulting hydrosol mixture was then caused to gel by gradually increasing the pH by dropwise addition of aqueous ammonia. Subsequent drying of the gelled material, followed by grinding and firing, yielded a fine-grained product that was shown by chemical and spectrographic analysis and X-ray diffraction to be mullite of theoretical composition and outstanding purity. A feature of the powder was the globular form of the particles, notably different from the acicular habit of mullite obtained in other procedures.

In a subsequent phase of the same research, experiments were carried out on the sintering of the newly available mullite powder under high pressure in an evacuated and induction-heated graphite die. Two journal articles were published presenting information on this experimental work and its conclusions.[12]

Orifice rings, vital components in automatic machines for mass production of glass containers, used to be fabricated from clay-bonded sillimanite or mullite, but the parts so obtained were often deficient in resistance to wear and thermal shock. A switch to harder high-alumina materials for this purpose has posed difficult machining problems with additional complications from the increasing demand for single-, double-, and triple-gob orifices in a profusion of shapes and sizes. Diamond-tool techniques in use by Emhart Corp., Hartford, Conn., for the precision coring of orifice blanks formed by slip casting or press extrusion of the newer materials were described in an industrial journal.[13]

[12] Ghate, B. B., D. P. H. Hasselman, and R. M. Spriggs. Synthesis and Characterization of High Purity, Fine Grained Mullite. Am. Ceram. Soc. Bull., v. 52, No. 9, September 1973, pp. 670–672.

Penty, R. A., D. P. H. Hasselman, and R. M. Spriggs. Pressure Sintering Kinetics of Fine Grained Mullite by the Change in Pressure and Temperature Technique. Am. Ceram. Soc. Bull., v. 52, No. 9, September 1973, pp. 682–693.

[13] American Ceramic Society Bulletin. Precision Orifice Rings Formed by Diamond Drills. V. 52, No. 9, September 1973, p. 690.

Lead

By J. Patrick Ryan [1]

World production and consumption of lead, continuing an upward trend, again reached record high levels in 1973. Free world mine production increased about 1%, with most of the net gain coming from Canada, Mexico and Peru. Refined lead production also was up about 1%. Consumption of metal rose nearly 5% and exceeded production, the deficit being balanced essentially by withdrawals from producers and Government stocks. The world production deficit and continued strong demand was reflected in rising prices. The monthly average London Metal Exchange (LME) cash price increased 86% and exceeded the U.S. producers average price during most of the year. The average equivalent LME price in 1973 was 19.47 cents. The average domestic price of lead on a nationwide basis in 1973 was 16.29 cents per pound.

Both domestic mine and smelter production of lead were down slightly in 1973 from the 43-year record high levels achieved in 1972. Output from the new Brushy Creek mine, which began production at midyear, was not enough to offset losses due to closure of the Federal and Mayflower mines late in 1972. Secondary smelter output increased 6% to 654,300 tons, a new record that amounted to nearly 49% of total smelter and refinery production of lead.

Demand for lead in the transportation field continued to grow as requirements for batteries and gasoline antiknock compounds together increased nearly 4%. The quantity of lead used in battery manufacture again reached a new record high, and lead used in antiknock additives was only slightly less than in 1972. Lead used in pigments increased 22%. Of the total lead consumption of 1.54 million tons, batteries accounted for 50%; antiknock compounds, 18%; pigments, 7%; ammunition, 5%; and solder, 5%.

Stocks of refined and antimonial lead at primary plants dropped from 64,500 tons at the beginning of the year to 26,100 tons at yearend. Consumer stocks increased from 118,500 tons at the beginning of the year to 124,000 tons at yearend. Commercial sales and transfers for Government use, totaling about 248,500 tons, reduced the total uncommitted Government stockpile inventory of lead to 829,100 tons at yearend.

American Smelting and Refining Company (ASARCO) and The Anaconda Company announced in August joint plans to accelerate development and bring the Ontario lead-zinc-silver mine at Park City, Utah, into production. Annual production of concentrates containing approximately 15,000 tons of lead, 25,000 tons of zinc, and 1.2 million ounces of silver is scheduled to begin in 1975.

Legislation and Government Programs.—The General Services Administration (GSA) reported that commitments to purchase surplus lead from the Government stockpile totaled 248,552 tons in 1973. Of the total, 238,913 tons represented commercial commitments through producers and the set-aside program; the remaining 9,639 tons represented transfers for Government use. The stockpile objective for lead was reduced to 65,100 tons by Excutive Order on April 12, 1973, thereby increasing the uncommitted surplus to 763,963 tons at yearend, of which 299,063 tons was available for disposal under legislation enacted in 1972. Actual physical drawdown of Government stocks during 1973 was 211,541 tons, leaving a total inventory in storage

[1] Physical scientist, Division of Nonferrous Metals—Mineral Supply.

of 874,330 tons on December 31.

Following reduction of the stockpile objective, an omnibus bill (H.R. 7153) was introduced in the Congress which would authorize the General Services Administrator to dispose of various materials from the national and supplemental stockpiles, including 464,900 tons of lead representing the difference between the old and new objectives. By yearend, no further action had been taken on the bill.

Bills (H.R. 3743, S607) to amend the Lead-Base Paint Poisoning Prevention Act were introduced in the 93d Congress, 1st session. These bills essentially provide for reducing the lead content of paints, conducting research to determine the safe level of lead in residential paint products, and would prohibit the use of lead-base paint in some consumer products and in future housing built with Federal aid. A compromise bill won final Congressional approval in October and became Public Law 93–151 on November 9. The lead and zinc flexible tariff bill (H.R. 6437) reintroduced in Congress in March contained a provision for increasing tariffs on lead in imported concentrates, unwrought and wrought metals, waste and scrap, and on manufactures of lead when exceeding specified limiting quantities. No further action was taken on the bill by the 93d Congress, 1st session.

On December 9, the Environmental Protection Agency (EPA) published revised regulations applicable to gasoline refiners designed to reduce the lead content of gasoline 60%–65% over a 5-year period, 1975–79. The new schedule, based on the total pool average lead content per gallon for each 3-month period, is as follows:

January 1, 1975	1.7 grams per gallon
January 1, 1976	1.4 grams per gallon
January 1, 1977	1.0 gram per gallon
January 1, 1978	.8 gram per gallon
January 1, 1979	.5 gram per gallon

The provision that at least one grade of lead-free gasoline—0.05 gram per gallon—be made available by July 1, 1974, remained unchanged.

Responding to lead dumping charges by the Bunker Hill Company, the U.S. Treasury Department made a determination in October that primary lead metal from Australia and Canada was being sold in the United States at less than fair market value within the meaning of the Antidumping Act. Following the determination by Treasury, the U.S. Tariff Commission instituted an investigation and held hearings in December on the question of injury, and on January 10, 1974, the Commission ruled that the dumping had caused or threatened injury to the domestic primary lead industry. As a result of the Commission's ruling, imports of primary lead from Australia and Canada sold at less than fair value will become subject to special dumping duties. On December 7, the Cost of Living Council removed its price control on lead and several other nonferrous metals to assure adequate domestic supplies of the metals vital for many capital-goods producers. The Council's action was said to be sufficient to encourage expansion of domestic capacity and supply as well as to bring domestic prices closer into line with world market prices.

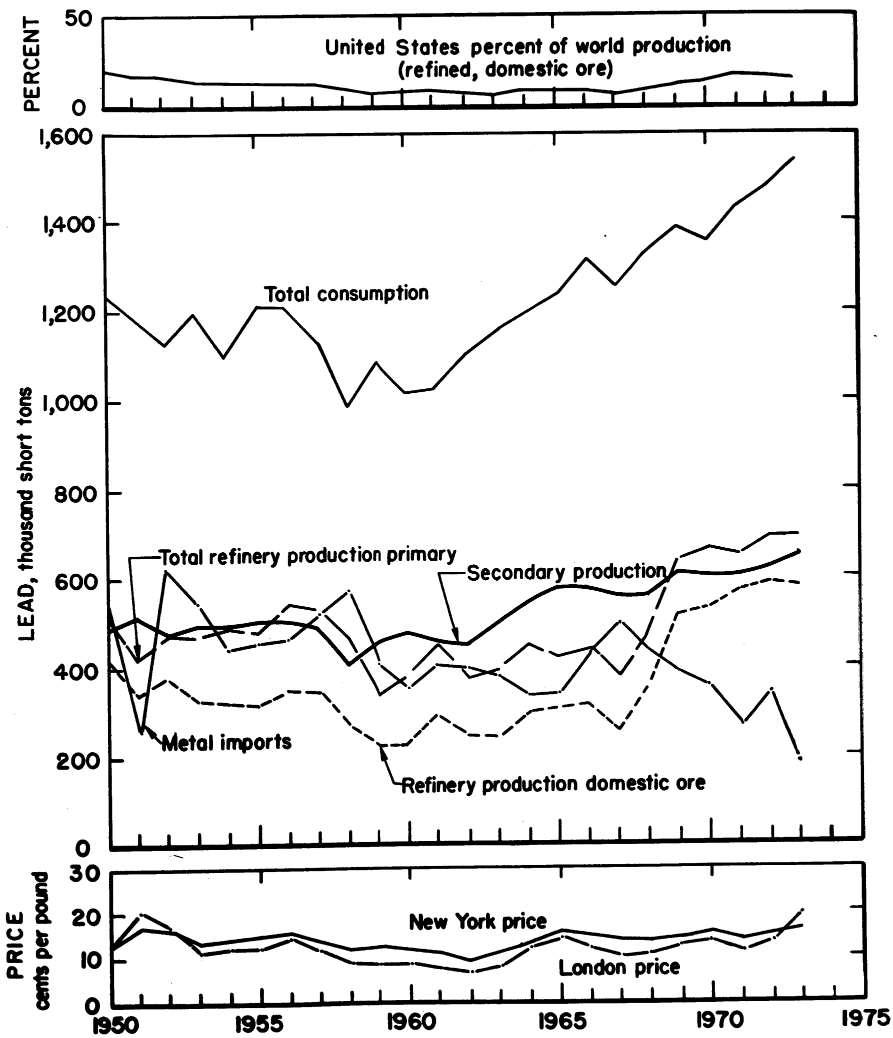

Figure 1.—Trends in the lead industry in the United States.

Table 1.—Salient lead statistics

(Short tons unless otherwise specified)

	1969	1970	1971	1972	1973
United States:					
Production:					
Domestic ores, recoverable lead content	509,013	571,767	578,550	618,915	603,024
Value ---------thousands--	$151,635	$178,609	$159,679	$186,046	$196,465
Primary lead (refined):					
From domestic ores and base bullion	513,931	528,086	573,022	r 577,398	567,256
From foreign ores and base bullion	124,724	138,644	76,993	103,001	107,260
Antimonial lead (primary lead content)	16,250	11,655	16,116	8,185	13,223
Secondary lead (lead content)	603,905	597,390	596,797	616,597	654,286
Exports of lead materials excluding scrap	4,968	7,747	5,925	8,376	66,576
Imports, general:					
Lead in ore and matte	109,252	112,406	65,998	101,514	102,483
Lead in base bullion	1,993	296	41	895	4
Lead in pigs, bars, and old	285,342	251,480	198,970	245,625	180,788
Stocks December 31 (lead content):					
At primary smelters and refineries	101,860	192,985	121,660	145,573	89,847
At consumer plants	126,404	133,502	125,577	118,544	124,121
Consumption of metal, primary and secondary	1,389,358	1,360,552	1,431,514	1,485,254	1,541,209
Price: Common lead, average, cents per pound [1]	14.93	15.69	13.89	15.03	16.29
World:					
Production:					
Mine	3,566,061	3,741,546	r 3,742,950	3,802,086	3,852,190
Smelter	3,553,458	3,628,422	r 3,590,730	3,744,660	3,800,753
Price: London, common lead, average, cents per pound	13.09	13.76	11.52	13.68	19.47

r Revised.

[1] Quotation for 1969–71 at New York and for 1972 and 1973 on a nationwide, delivered basis.

DOMESTIC PRODUCTION

MINE PRODUCTION

After rising for 5 consecutive years to a 43-year high in 1972, mine production dropped about 3% in 1973 to 603,000 tons. Monthly production reached a maximum of 55,900 tons in May, slightly less than the maximum achieved in 1972. Production from Missouri mines, which accounted for 81% of the Nation's total, was down slightly. Output in Idaho, which provided 10% of the total, was virtually unchanged. Utah's output dropped sharply following the closure of the Mayflower mine at year-end 1972. Output of lead at Kennecott's Burgin mine also was lower than in 1972 due to a shortage of skilled miners together with delays attributed to adverse underground mining conditions.[2]

The Buick mine jointly owned by Amax Lead Co. of Missouri (AMAX) and Homestake Mining Co. was again the leading lead producer with an output of 1.6 million tons of ore, an increase of 10% over that of 1972. Production of lead concentrate was up 19% to 225,000 tons. The six leading mines, all in Missouri, contributed 75% of the total U.S. mine production of lead. The 10 leading mines produced 86%, and the 25 leading mines contributed 99%. About 4,900 persons were employed in the Nation's lead, lead-silver, and lead-zinc mines and mills in 1973. Output of lead and zinc from these mines per man year was approximately 150 tons. Average grade of lead ore mined was 6.55% lead and 1.08% zinc compared with 5.89% lead and 0.73% of zinc in 1972.

St. Joe Minerals Corp. reported that output from its southeast Missouri mines declined 29,000 tons to 283,602 tons owing to the phasing-in of its new production facilities at Brushy Creek, which replaced the Federal mine in the Old Lead Belt that closed in October 1972. St. Joe, the Nation's largest lead mining company has four mine-mill operations in the New Lead Belt of southeast Missouri: Fletcher, Viburnum, Indian Creek, and Brushy Creek. The company stated that the higher grade ore (4%–8%) and improved mining and milling technology in the New Lead Belt operations has brought a substantial increase in productivity compared with operations in the Old Lead Belt. St. Joe estimates its proven

[2] Kennecott Copper Corp. 1973 Annual Report. P. 11.

lead reserves at 50 million tons—enough for 15 years production at the current rate of mining—and its probable ore reserves at an additional 100 million tons, or 30 years of production.[3]

Ozark Lead Co. produced 59,199 tons of lead in concentrate from its Ozark mine operations compared with 69,100 tons in 1972. The falloff in production resulted from a 2-month labor strike and a shortage of skilled underground maintenance personnel.[4]

The Bunker Hill Company reported that production of lead from company owned and controlled mines in Idaho aggregrated 31,000 tons, about the same as in 1972. The company reported that proven and probable ore reserves at yearend in the Bunker Hill mine totaled 2.01 million tons averaging about 3.6% lead, 5.1% zinc, and 2.1 ounces of silver per ton.[5] Hecla Mining Co. reported that ore production at the Star-Morning mine, jointly owned by Hecla (30%) and Bunker Hill (70%), increased 2,200 tons to 265,780 tons. Hecla's share of the 1973 production of lead-zinc-silver ore was 79,734 tons assaying 5.18% lead, 6.68% zinc, and 2.79 ounces of silver per ton. Hecla's share of the computed ore reserves increased 21,000 tons to 286,000 tons at yearend. Hecla's Lucky Friday mine produced 176,859 tons of silver-lead-zinc ore assaying 11.2% lead, compared with 192,020 tons assaying 10.4% lead in 1972. The decline in 1973 mine output was attributed largely to a continued shortage of skilled underground miners. Ore reserves at Lucky Friday at yearend totaled 510,000 tons, about 74,000 tons less than a year earlier.[6]

Lead output in Colorado, reversing the rising trend of the preceding 5 years, declined about 3,200 tons to 28,100 tons in 1973. Both the Leadville unit (Resurrection mine) and the Idarado Mines reported lower production during the year. The Leadville unit, a joint venture of ASARCO and Newmont Mining Corp., produced 199,000 tons of lead-zinc-silver ore and recovered 7,200 tons of lead.[7] Owing largely to a manpower shortage, the mine did not produce at more than about 75% of its rated capacity of 700 tons of ore per day during the year. Ore reserves at yearend were estimated at 2.62 million tons averaging 4.98% lead, 9.71% zinc, 2.53 ounces of silver and 0.067 ounce of gold per ton. Idarado Mining Co. mined and milled 378,200 tons of lead-zinc-copper ore in 1973 compared with 386,500 tons in 1972. Ore reserves at yearend 1973 were 3.24 million tons averaging 3.36% lead, 4.61% zinc, 0.77% copper, 1.77 ounces of silver and 0.02 ounce of gold per ton.

Park City Ventures, jointly owned by The Anaconda Company and ASARCO, announced in August plans to continue development and to commence operations at the Ontario lead-zinc-silver mine at Park City, Utah. Development plans include deepening the production shaft to the 2,500-foot level and construction of a 700-ton-per-day flotation concentrator. Mine production at a rate of 5,000 tons of ore per week is scheduled to commence in early 1975. Officials estimated that 43,000 tons of zinc concentrate, 25,000 tons of lead concentrate and 1.2 million ounces of silver will be produced annually. The Ontario was the original mine in the Park City district and operated more or less continuously from 1872 until 1970.

SMELTER AND REFINERY PRODUCTION

Reversing the rising trend since 1967, output of lead at the four primary refineries in 1973 was slightly less than the 43-year record high production established in 1972. The gain in metal recovered from foreign ores and concentrates did not fully offset the decline in metal recovered from domestic concentrates. Production from domestic primary sources was down about 7,300 tons; the gain from foreign sources was about 6,400 tons. About 84% of the 674,500 tons of primary lead produced was derived from domestic ores compared with 85% in 1972. Antimonial lead production at primary refineries, after declining for 4 consecutive years, increased slightly to nearly 14,300 tons because the average antimony content of ores increased 0.5% to 7.5%.

The Herculaneum, Mo., smelter of St. Joe Minerals Corp. produced 215,000 tons of lead metal and alloys, about 7,100 tons more than in 1972. The smelter operated below its 230,000-ton rated capacity because

[3] St. Joe Minerals Corp. 1973 Annual Report. Pp. 2, 7, 9.
[4] Page 11 of work cited in footnote 2.
[5] Gulf Resources & Chemical Corp. 1973 Annual Report. Pp. 5, 7.
[6] Hecla Mining Co. 1973 Annual Report. Pp. 6–7.
[7] ASARCO. 1973 Annual Report. P. 20. Newmont Mining Corp. 1973 Annual Report. Pp. 9–10.

of a planned 3-week shutdown to install new environmental control equipment.[8]

ASARCO reported that its lead smelters maintained production at 1972 rates but continued to operate below capacity owing to environmental restrictions. The Glover, Mo., custom smelting and refining plant produced 82,300 tons of lead compared with 86,400 tons in 1972. Most of the concentrate treated at the Glover plant continued to come from the Ozark mine at Sweetwater, Mo. Concentrates from nine other domestic mines in four States and from one mine in Honduras also were treated at Glover. The East Helena, Mont., smelter operated continuously during the year processing crude ore and concentrates from about 94 domestic mines in 9 States and from mines in Canada, Peru, Colombia, and Australia. The El Paso, Tex., lead smelter processed ores and concentrates from approximately 24 domestic mines in 6 States and from mines in Peru, Canada, Honduras, Nicaragua, Australia, and Mexico. Refined metal output at the company's Omaha, Nebr., refinery, which processed lead bullion from the East Helena and El Paso smelters, totaled 165,100 tons, 22,400 more than in 1972.

AMAX reported that its smelter at Buick, Mo., produced 135,000 tons of refined lead in 1973, about 2,000 tons more than in 1972. About 57% of the total production was for the owners' account, and the remainder was refined on toll for other producers.[9]

The Bunker Hill smelter-refinery of Gulf Resources & Chemical Corp. at Kellogg, Idaho, operated continuously, except for a 4-day strike shutdown, and produced 130,200 tons of lead in all forms, about 1,600 tons less than in 1972. The reduction in output was due in part to the work stoppage and partly to efforts to comply with air pollution standards.[10] The company treated concentrates from nine domestic mines in five States and from mines in Canada.

Secondary smelter production of lead from recycled materials increased about 37,700 tons to a new record output of 654,300 tons, about 49% of the total smelter and refinery production. Approximately 140 secondary plants were engaged in recovery of lead and lead alloys from scrap materials during the year. Secondary output represented about 42% of total lead consumption in 1973.

[8] Page 9 of work cited in footnote 3.
[9] AMAX. 1973 Annual Report. Pp. 16–17.
[10] Page 7 of work cited in footnote 5.

Major secondary smelting companies reporting to the Bureau of Mines

Company	Plant
American Smelting & Refining Co. (including Federated Metals Div.)	San Francisco, Calif., Whiting, Ind., Omaha, Nebr., Newark, N.J., Houston, Tex.
East Penn Mfg. Co	Lyons Station, Pa.
General Battery Corp	Reading, Pa.
Gopher Smelting & Refining Co	St. Paul, Minn.
Gould, Inc	Omaha, Nebr., Philadelphia, Pa.
Nassau Smelting & Refining Co	Tottenville, N.Y.
NL Industries, Inc. (including Magnus Metal Division and Master Metals, Inc.)	French Camp and Los Angeles, Calif., Atlanta, Ga., Chicago and Granite City, Ill., Detroit, Mich., St. Louis Park, Minn., St. Louis, Mo., Fremont, Nebr., Pedricktown and Perth Amboy, N.J., Cincinnati and Cleveland, Ohio, Dallas and Houston, Tex.
RSR Corp. (including Murph-Murdock Division and Quemetco Division).	City of Industry, Calif., Indianapolis, Ind., Middletown, N.Y., Dallas, Tex., Seattle, Wash.
Richardson Graphics	Chicago, Ill., Philadelphia, Pa.
Schuylkill Metal Corp	Baton Rouge, La.
Seitzinger's Inc	Atlanta, Ga.
Selco, Div. of Contract Manufacturers, Inc	Tampa, Fla., Columbus, Ga., Florence, Miss.
U. S. S. Lead Refinery, Inc	East Chicago, Ind.
Hyman Viener, and Sons	Richmond, Va.
Willard Smelting Co	Charlotte, N.C.

RAW MATERIAL SOURCES

Domestic mines delivered 603,000 tons of recoverable lead in concentrates to six domestic primary smelters. This represented 88% of the total production of 687,700 tons of primary refined lead and antimonial lead, about the same proportion as in 1972. Lead recovered from imported concentrates smelted during the year amounted to nearly 111,500 tons, about 6,500 tons more than in 1972. Lead recovered from lead scrap processed at primary plants dropped to about 1,100 tons contained in antimonial lead compared with a total of 7,000 tons in 1972. Raw material stocks at the beginning of the year at primary plants totaled 197,300, of which 101,900 tons was in process and 2,500 tons was in secondary materials. At yearend, stocks of primary materials awaiting process contained 88,500 tons of lead, material in process 78,200 tons, and secondary material 2,800 tons, a total of 169,500 tons.

Scrap materials consumed in 1973 totaled 867,800 tons, 53,400 tons more than in 1972. About 98 secondary smelters accounted for nearly all of the total scrap consumed. New scrap in the form of purchased drosses and residues from a wide variety of sources aggregated 154,700 tons, about 18% of the total input. The remainder, old scrap, was predominantly battery scrap, with lesser quantities of cable lead, type metal, solder, babbitt, and soft and hard lead. Nearly all of the scrap processed originated from domestic sources. General imports of reclaimed scrap, mainly from Australia, totaled nearly 2,700 tons (lead content), about 17% less than in 1972, but exports of lead scrap totaled nearly 60,000 tons, about 24,700 tons more than in 1972. Stocks of scrap at smelters increased 18,000 in 1973 tons to 84,300 tons at yearend.

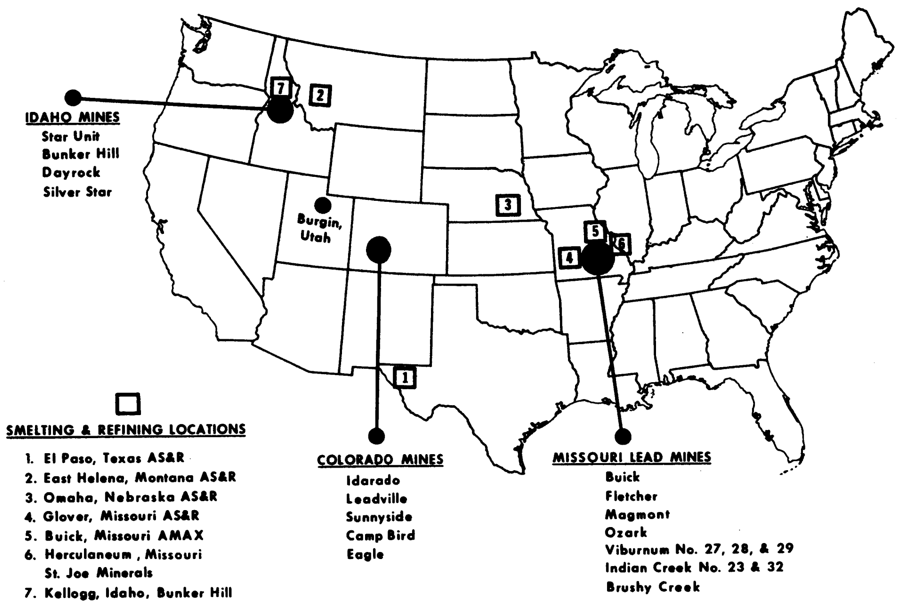

Figure 2.—Lead mines and smelters in the United States.

CONSUMPTION AND USES

Lead consumption in the United States increased nearly 4% in 1973 to a new record of 1.54 million tons. Monthly requirements ranged from a new record high of 143,200 tons in March to a low of 101,900 tons in July. In the metal products category, which accounted for 72% of the total lead consumption, the 6% increase in battery requirements more than offset combined decreases in ammunition, cables, calking, and tubes. Significant gains also were recorded in the quantity of lead used in brass, pipes, terne and type metals. The growth in requirements for battery lead largely reflected the continued increase in the number of both on-the-road and off-the-road motor vehicles that use battery power for starting, lighting, ignition (SLI), and traction. A total of 57.1 million SLI-type batteries were produced in 1973, about 43.4 million of which were for replacement, 12.6 million were original equipment, and the remainder were exported. The quantity of lead used in gasoline antiknock compounds decreased 1.4%, reflecting a reduction in the average lead content per gallon of gasoline from about 2.6 grams per gallon in 1972 to about 2.2 grams per gallon in 1973.

Soft refined lead represented 66% of the total consumption, antimonial lead accounted for 29%, and lead in other alloys mainly solders and bearing metals, accounted for 4% of the total. Lead in copper-base scrap accounted for 1% of consumption.

The domestic supply of lead metal from all sources—primary and secondary production, imports for consumption, stock changes, and stockpile releases—totaled about 157,000 tons more than reported consumption and exports. The apparent excess supply in 1973 amounting to about 10% of reported consumption was attributed partly to unreported consumption and stock buildup, especially by small producers and dealers that do not report to the Bureau of Mines.

The compound annual growth rate in lead consumption during the 10-year period 1964–73 averaged about 2.5% owing largely to increased demand for batteries, which showed an annual growth of 6% during the period and accounted for approximately 50% of the total domestic consumption in 1973 but only 37% in 1964. Per capita lead consumption was 14.6 pounds compared with 14.2 pounds in 1972.

Lead used in pigments, particularly red lead and litharge, increased 28% and accounted for 7% of the total consumption in 1973. Lead antiknock compounds, and miscellaneous and other unclassified uses decreased slightly and accounted for 18% and 3% of the total, respectively. Lead used in other metal products, virtually the same as in 1972, accounted for 22% of the total.

The Lead Industries Association (LIA) reported the expanding use of terne-coated stainless steel in exposed architectural applications for protection against corrosion. The terne metal alloy coating is 80% lead and 20% tin. LIA also reported the increasing use of sheet lead in sound barrier applications such as accoustical polyurethane foam material used in machinery noise control panels designed to meet Occupational Safety and Health Administration (OSHA) standards.

LEAD PIGMENTS

Lead requirements for the production of lead oxides and pigments totaled 510,000 tons, about 13% more than in 1972. The quantity of lead used in making both white and red lead decreased and constituted only 4% of the total lead consumed in pigments and oxides. Litharge production used about 32% of the total lead requirements, and black oxide production used 64% of the total. Most of the litharge shipments went to battery manufacturers and is included in "Other" in table 20. Litharge shipments increased nearly 31,500 tons and comprised 75% of the total shipments in 1973. Litharge shipped for use in the ceramics industry increased 55% in 1973 and amounted to 20% of the total shipments for the year.

Prices.—The price of basic carbonate white lead in carload lots, freight allowed, remained unchanged at 23.9 cents per pound. The quoted price of red lead oxide (Pb_3O_4) 95%, in carload lots at works, was advanced from 18.75–18.90 cents per pound in January to 19.25 cents in February, 20.25–20.45 cents in April, 20.75–21.20 cents in May, to 21–21.20 cents in June, and remained unchanged thereafter to yearend. The price quotation on lead silicate ($PbSiO_2$) ranged upward from 20.75–21.75 cents per pound in January, 21.75 cents in April, to 23.0 cents in June and was unchanged thereafter. The price quotation of commercial-grade litharge, powdered, in carload lots at works ranged upward from 18 cents per pound in January to 19.5 cents in April, 20–20.25 cents in May, to 20.25 cents in June, and remained unchanged to December when the price quotation was advanced to 21.25–22.75 cents.

The value of shipments of white lead, red lead, and litharge amounted to $72.9 million in 1973, an average of $356 per ton compared with $61.1 million and $344 per ton in 1972.

Foreign Trade.—Exports of pigment-grade lead oxides totaled 290 tons valued at $132,700 and exports of lead oxides other than pigment grade amounted to 61 tons valued at $60,500. Shipments went to 36 countries.

Imports for consumption of lead pigments and compounds decreased 23% in quantity and 7% in value to $8.6 million. Litharge, which comprised 70% of the total imports, decreased 7%; imports of chrome yellow, comprising 22% of the total, were 40% less than in 1972. Mexico supplied virtually all the imports of litharge; most of the chrome yellow came from Japan.

STOCKS

Inventories of refined and antimonial lead at primary refineries declined steadily through the first 7 months then trended upward in the last 5 months from the July low. Metal stocks totaling 64,500 tons at the beginning of the year decreased to about 26,100 tons at yearend. Stocks of lead in base bullion declined about 2,700 tons during the year, but the lead content of ore and matte stocks declined nearly 14,700 tons.

Stocks of lead in all forms at consumer and secondary smelting plants totaled 124,100 tons at yearend, indicating an increase of about 5,600 tons during the year. Refined soft lead constituted 68% of the total compared with 62% of the total in 1972.

Stocks of lead at producers and consumers plants totaling about 214,000 tons represented less than a 2-month domestic consumption.

PRICES

The U.S. producer price for common-grade lead on a nationwide basis was reported by Metals Week at 14.50 cents per pound on January 1, was advanced 0.5 cent to 15.0 cents on January 12, to 15.5 cents on February 6, and 16.0 cents on March 6. On April 30, the price quotation became split at 16.0–16.5 cents continuing unchanged at 16.5 cents per pound to June 1. Thereafter, the price was frozen at this level under price control regulations until December 6 when the controls on lead were lifted by the Cost of Living Council. On December 10, the producers quoted price was increased to a range of 18–19 cents per pound. The average monthly producer price increased from 14.50 cents in December 1972 to 17.72 cents in December 1973, a 22% gain during the year. The average price for the year was 16.29 cents compared with 15.03 cents in 1972.

The London Metal Exchange (LME) price, in terms of U.S. currency, reflected strong world demand and increased steadily from a low average of 14.42 cents in January to 22.13 cents in November, rising sharply early in December to a high of 30.28 cents and averaging 26.84 cents for the month. The average LME cash price for the year was 19.47 cents, based on the monthly average Sterling Exchange rate of 245.10 cents, compared with an average price of 13.68 cents in 1972. The LME quotation exceeded the U.S. price for the first time in 8 years.

FOREIGN TRADE

Exports of lead metal and scrap materials increased sharply due principally to world prices being substantially higher than domestic prices, which were frozen for most of the year. The outflow of lead materials and scrap (126,450 tons) was nearly 3 times the quantity exported in 1972 and a new record. Wrought and unwrought metal constituted 53% of the total exports, most of which went to Japan, the Netherlands, and Italy; the remaining 47% was contained in scrap materials, most of which was shipped to Canada, Japan, and Brazil.

General imports of lead materials into the United States dropped nearly 19% to a total of 283,300 tons valued at $76.1 million. Receipts of lead in concentrates and other crude materials were near the same level as in 1972, but metal receipts dropped nearly 27% to about 178,096 tons, the smallest quantity of metal imports since 1951. The decline in lead imports was attributed partly to price regulations in the United States and partly to the effect of dumping charges filed against Canadian and Australian exporters by a major domestic producer and the subsequent determination by the U.S. Treasury Department sustaining such charges. Peru was the leading supplier of crude lead materials with nearly 23% of the total, followed by Australia, Honduras, and Canada. Canada continued to be the leading metal supplier with 35% of the total, followed by Australia 26%, Peru 24%, and Mexico 11%.

WORLD REVIEW

In 1973 mine production of lead in non-Communist countries (which includes Yugoslavia) based on data compiled by the Bureau of Mines totaled 2.95 million tons, about 7% more than in 1972. The Bureau estimated mine production in Communist countries at 0.87 million tons. Smelter output of lead in 1973 in non-Communist countries, reported as primary metal insofar as possible to determine by the Bureau, totaled 2.92 million tons. In addition, the Bureau of Mines estimated 0.88 million tons of metal produced in Communist countries to provide a world total of 3.80 million tons of primary lead, about 1% more than in 1972.

The United States maintained its rank as the leading mine producer of lead in 1973, accounting for approximately 16% of the world total, followed by the U.S.S.R., Australia, Canada, Peru, Mexico, and Yugoslavia, each with production exceeding 100,000 tons of lead in ore mined; these seven countries produced 67% of the world total. The 1% gain in the non-Communist country lead output was largely due to production gains in Mexico, Peru, Canada, Yugoslavia, Morocco and Australia, which more than offset losses in Japan, Spain, and the United States. The North America area increase was about 1% and the 1.21 million tons produced represented 41% of the non-Communist country total and 31% of the estimated world total.

The United States also continued to be the leading producer of primary lead metal as well as secondary lead. The U.S.S.R. again ranked second, followed by Australia, Japan, Canada, Mexico, France, the People's Republic of China and Bulgaria. The nine countries each produced more than 100,000 tons and together accounted for 69% of the world total. The North America area accounted for 37% of the non-Communist country metal output and 28% of the estimated world output (excluding U.S. secondary production). The 1% gain in primary metal output by non-Communist countries came chiefly from increases in Australia, Mexico, and Japan. The smelter output data for some countries, particularly France, Japan, and West Germany, includes secondary metal.

According to preliminary data compiled by the International Lead and Zinc Study Group (ILZSG), consumption of refined lead in 1973 by non-Communist countries amounted to 3.8 million tons, about 5% more than in 1972. Most of the increase came from West European countries and Japan. The U.S. accounted for about 40% of the non-communist total consumption. ILZSG comparative statistics on metal production and consumption in non-Communist countries indicate a new supply deficit of about 90,400 tons in 1973, compared with an indicated surplus of 33,000 tons in 1972. The indicated deficit was reflected in producers stocks, which declined about 106,000 tons during the year to nearly 160,000 tons at yearend. Consumers' stocks in the United States, the United Kingdom, and Japan combined decreased about 23,700 tons to 172,000 tons at yearend.

Trade data for the first 9 months of 1973 compiled by ILZSG disclosed that imports of lead bullion and refined lead into Communist countries from the rest of the world totaled about 58,200 tons, 19,700 tons more than exports compared with 40,800 and 11,000 tons, respectively, in the corresponding period of 1972.

Australia.—Mine output of lead increased nearly 1% to 447,000 tons, and Australia maintained its rank as the world's third ranking lead-producing country.

M.I.M. Holdings Limited treated 2.26 million tons of silver-lead-zinc ore at its Mount Isa operations averaging 6.6% lead and recovered 124,000 tons of lead bullion, 3,800 tons less than in 1972. In June 1973, the company reported primary silver-lead-zinc ore reserves at the Mount Isa mine at 60.6 million tons averaging 6.9% lead, 6.4% zinc, and 4.8 ounces of silver per ton. At the Hilton mine primary silver-lead-zinc ore reserves were estimated at 40.8 million tons averaging 5.8 ounces of silver per ton, 7.7% lead, and 9.6% zinc.[11]

Lead production at the Port Pirie smelter operated by Broken Hill Associated Smelter, Pty. Ltd. was 201,660 tons, nearly 19,000 tons less than in 1972.

E.Z. Industries Ltd. continued to expand productive capacity at its West Coast mines in Tasmania. During the year, the company milled 546,600 tons of zinc-lead-copper ore chiefly from the Rosebery and Hercules mines containing 5.3% lead and recovered nearly 25,200 tons of lead concentrate, a 15% gain in ore milled and a 5% gain in output of lead concentrate compared with production in 1972. The higher mine output achieved under the double production capacity plan was partially offset by the effects of a 5-week labor strike. The adoption of long-hole open stope drilling and improved loading equipment contributed to the increased tonnage mined at the Rosebery mine compared with that of the preceding year. Ore reserves totaled 10.3 million tons at fiscal yearend. About 96% of the total reserve was in the Rosebery mine; the remainder was in the Hercules and Farrell mines.[12]

North Broken Hill Ltd. reported that it mined 556,700 tons of lead-zinc-silver ore, about 6,000 tons less than in 1972. The grade of ore was 12.4% lead, 9.20% zinc, and 6.2 ounces of silver per ton, and production was 91,700 tons of lead concentrate containing 67,250 tons of lead and 29.2 million ounces of silver. Ore reserves on June 30 totaled 5.0 million tons, about the same as last year.[13]

Canada.—Canadian mine output of lead contained in ores and concentrates increased 2% in 1973 to 427,400 tons. The gain in output came chiefly from increases at mines in the Yukon and Northwest Territories and British Columbia, which together accounted for about 84% of the total production.

Cominco, Ltd. reopened its H.B. mine in British Columbia in February and brought output up to rated capacity of 1,000 tons per day in March. The mine had been closed since 1965. Cominco also continued development of the Polaris mine, which is jointly owned by Cominco (75%) and Bankeno Mines Ltd. (25%), on Little Cornwallis Island in the Northwest Territories and shipped 3,600 tons of ore for metallurgical tests. Nigadoo River Mines Ltd. began unwatering its New Brunswick mine in preparation for resuming operations that were discontinued in 1971. The 1,000-ton-per-day concentrator is scheduled for capacity production by mid-1974. Ore reserves were estimated at 1.2 million tons averaging 3.2% lead, 3.2% zinc, 0.2% copper, and 4.0 ounces of silver per ton.

Cominco, Ltd. continued to operate its Sullivan mine in British Columbia, the Pine Point mine in the Northwest Territories, and the Trail smelter which treated company and custom lead-zinc ores. Ore production at the Sullivan mine was increased about 15% to 2.21 million tons with a combined lead-zinc content of 10.0%; Pine Point ore production was 3.90 million tons averaging 8.9% combined lead-zinc and yielding 131,400 tons of lead concentrate. Lead produced at Trail from all sources totaled 172,000 tons, about 2,000 tons more than in 1972. Ore reserves at the Sullivan and H.B. mines totaled 62.0 million tons containing 6.7 million tons combined lead and zinc. Pine Point reserves totaled 38.0 million tons containing 3.1 million tons of zinc and lead. The company also reported zinc-lead ore reserves at the Polaris mine of 25.0 million tons containing 4.7 million tons of combined zinc and lead.[14]

Brunswick Mining and Smelting Corp. Ltd. reported that it milled 3,288,100 tons of lead-zinc ore yielding 153,500 tons of lead concentrate, about 19,400 tons less than in 1972. Preliminary conversion of the Imperial Smelting Process (ISP) lead-zinc smelter to a smelter treating lead con-

[11] M.I.M. Holdings Limited. 1973 Annual Report. Pp. 5, 7.
[12] E. Z. Industries Ltd. 1973 Annual Report. Pp. 9–11.
[13] North Broken Hill Ltd. 1973 Annual Report. Pp. 2, 8, 16.
[14] Cominco, Ltd. 68th Annual Report. 1973. P. 89.

centrate only was completed in the second quarter, and 34,450 tons of refined lead was produced compared with 35,980 tons in 1972 (including 7,100 tons of lead purchased and upgraded). Reserves of lead-zinc ore in the No. 12 mine at yearend were 84.7 million tons averaging about 3.8% lead, 9.4% zinc, 0.27% copper, and 2.8 ounces of silver per ton. An additional 3.4 million tons of proven reserves were in the No. 6 mine.[15]

Primary lead output from Canada's two refineries, one at Trail, British Columbia, operated by Cominco, Ltd, and one at Belladune, New Brunswick, operated by Brunswick Mining and Smelting Corp. Ltd., decreased about 3,400 tons to 202,500 tons. Conversion of Brunswick's ISP plant to a straight lead blast furnace and the addition of new refining equipment are expected to increase capacity from 33,000 to 70,000 tons per year when fully operative.

Anvil Mining Corp., a 60%-owned subsidiary of Cyprus Mines Corp., mined 2.90 million tons of lead-zinc-silver ore averaging 4.9% lead, 6.4% zinc, and 1.6 ounces of silver per ton from its open pit mine and concentrating facility in the Yukon Territory. Concentrates produced contained 111,700 tons of lead, 118,100 tons of zinc and 2.58 million ounces of silver. Ore reserves at yearend were estimated at 52.6 million tons with an average grade of 3.1% lead, 5.5% zinc, and 1.1 ounces of silver per ton. At the current mining rate, reserves will last about 14 years.[16] Most of Anvil Mining production is sold in Japan and West Germany.

Exports of lead in ores and concentrates increased 8% to 193,400 tons. Refined metal exports totaling 113,600 tons were about 19% less than in 1972. Shipments to the United States accounted for 42% of the total; 44% went to the United Kingdom, and the remaining 14% was shipped to 19 other countries.

Greenland.—Vestgron Mines Ltd., a 63%-owned subsidiary of Cominco, Ltd., began production at the Black Angel mine near Marmorilik in October at the rate of 1,800 tons of ore per day. One shipment of about 20,000 tons of concentrate was made before the fiord was closed by ice. Concentrates were stockpiled for shipment to European smelters in the spring of 1974.[17]

Honduras.—Rosario Resources Corporation reported that it processed 311,600 tons of ore averaging 8.4% lead, 10.0% zinc, and 11.9 ounces of silver per ton in 1973 and recovered lead concentrates containing 21,160 tons of lead along with silver, gold, and zinc. The quantity of ore treated in 1973 was slightly less than in 1972, but average ore grade and metals recovered were greater than in 1972. Assured and probable ore reserves in the main mine area decreased by 153,200 tons to 1.79 million tons grading 10.5% lead, 10.9% zinc, 12.2 ounces of silver, and 0.008 ounce gold per ton. Ore reserves developed in the San Juan ore body increased to 3.05 million tons grading 2.8% lead, 7.5% zinc, 0.3% copper, 2.9 ounces of silver, and 0.002 ounce of gold per ton. Total reserves for both mine areas increased by 54,700 tons to 4.88 million tons averaging 5.6% lead, 8.8% zinc, 0.4% copper, 6.3 ounces of silver, and 0.005 ounce of gold per ton.[18] Mine expansion in progress in 1973 included extending the main production shaft 500 feet to the 2,225 level and the development of the San Juan ore body scheduled for initial production in 1974.

Ireland.—Tara Exploration and Development Co. Ltd. reported that its target date for initial production at its Navan mine was revised to late 1975 as a result of delays in obtaining final planning permission to construct surface facilities and the issue of a State mining license. The company reported that the development shaft was advanced to 1,105 feet, only 15 feet short of its target depth of 1,120 feet and that it expected to begin hoisting development ore in July 1974. About 250 feet was raised in the production shaft, which was scheduled to be completed and fully equipped by October 1975. The underground decline tunnel system has now advanced over 6,000 feet.[19]

At the Tynah mine, Irish Base Metals Ltd. milled 529,400 tons of ore yielding concentrates containing 45,000 tons of lead, 16,400 tons of zinc, 1,350 tons of copper, and 1.46 million ounces of silver. Open pit ore was completely extracted and mine operations were wholly underground at yearend.

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[15] Brunswick Mining and Smelting Corp. Ltd. 21st Annual Report. 1973, p. 5–6.

[16] Cyprus Mines Corp. 1973 Annual Report. Pp. 12–13.

[17] Page 25 of work cited in footnote 14.

[18] Rosario Resources Corporation. 1973 Annual Report. Pp. 6–7.

[19] Tara Exploration and Development Co. Ltd. 1973 Annual Report. Pp. 7, 11.

The new Irish Government announced that it will withdraw the 20-year tax exemption on mineral deposits brought into production before 1986.

Mexico.—ASARCO Mexicana, S.A., 49%-owned by ASARCO, reported normal operations at its mines and improved operations at the Chihuahua lead smelter in 1973. Production of refined lead increased 10,700 tons to 86,300 tons.[20]

The Fresnillo Co. reported that it mined a total of 1.5 million tons of lead-zinc-silver ore at its Mexican properties and recovered 40,967 tons of lead, 43,000 tons of zinc, and 4.3 million ounces of silver. Most of the metal production came from the Naica and Fresnillo units. Ore reserves at yearend declined about 3% to 4.9 million tons averaging 4.0% lead, 4.4% zinc, and 4.8 ounces of silver per ton.[21]

Peru.—Cerro Corp. reported that its Peruvian operations continued at near record levels during 1973. Refined lead production was 91,300 tons, about 3,000 tons less than in 1972. Approximately 25% of the total lead output came from purchased ores, compared with 47% in 1973. Cerro's subsidiary, Cerro de Pasco Corp., which operated the mines and smelter complex in Peru for 72 years, was expropriated by the Peruvian government effective at yearend.[22]

Lead production in Peru, comprising lead in concentrate for export plus refined lead and lead alloys in smelter products, increased nearly 5% to 218,800 tons.

Nicaragua.—Neptune Mining Co., operated by ASARCO, treated 177,500 tons of ore at the Vesubio lead-zinc mine, and recovered concentrates containing 3,000 tons of lead and 20,600 tons of zinc, an increase of 37% and 26%, respectively, over output in 1972. Development work resulted in increased ore reserves.

Tunisia.—Production of lead ore from Tunisian mines dropped 22% in 1973 to 28,430 tons. However, both production and export of refined lead increased slightly. Imported lead ore, primarily from Algeria and Morocco, totaling 27,950 tons (60% to 70% lead), was blended with domestic ores, which average 40% to 50% lead. Exports of refined lead totaled 25,990 tons, most of which went to Italy and Greece.

Yugoslavia.—Trepca Corp. continued expansion and modernization at its Stari Trg mine scheduled for initial operations in 1975 at a rate of 1 million tons per year. Output of 3 million tons of lead-zinc ore per year is planned by 1977. Annual output from the Trepca complex will be increased to 167,000 tons of lead. The new Zletovo ISP zinc-lead smelter at Titov Veles, Macedonia began production in May. The smelter complex consists of a sinter plant, sulfuric acid plant, an Imperial Smelting furnace plant, and zinc and lead refineries. Output of lead at the plant is expected to total 35,000 tons, which will increase Yugoslavia's smelting capacity to 210,000 tons of lead per year.

TECHNOLOGY

Research and development activities in the lead industry were primarily directed toward improving and expanding current applications of the metal to maintain optimum growth.

The International Lead Zinc Research Organization (ILZRO) continued its cooperative research in such general areas as architectural applications, wrought lead applications, cable sheathing, batteries, organolead chemicals, ceramics, and environmental health. A major effort in the architectural area resulted in the development of single-family dwelling concepts featuring new and conventional applications of lead. The prototype house will be capable of quick assembly by unskilled labor using a few simple tools; it will be expandable and contractible and will be thermally and acoustically efficient. The ILZRO house of modular design is primarily metal and the materials are recyclable, thus minimizing pollution and promoting conservation. Research continued on developing lead-plastic laminates suitable for all types of packaging applications and for possible use as cable sheathing where resistance to water vapor penetration is required. In the battery field ILZRO, in cooperation with a manufacturer, designed and constructed prototype test vans powered by lead-acid batteries that may establish the advantages and prac-

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[20] Page 19 of first work cited in footnote 7.

[21] The Fresnillo Co. 1973 Annual Report. Pp. 10–11.

[22] Cerro Corp. 1973 Annual Report. Pp. 16–17.

ticability of using electric vehicles in the transportation field. In the ceramics area, ILZRO research efforts developed basic information on the structure, composition and properties of leaded-glass systems. ILZRO participated in various environmental health projects dealing with the effects of lead on biological organisms. In one such project, ILZRO reported that a comparison of the health of workers in the lead industries demonstrated that lead workers had a longevity better than that of the general population.

Cominco, the largest Canadian lead and zinc producer, reported substantial progress in the pilot-plant study of its new process that could make present conventional lead smelting operations obsolete. The new process, which has already cost $1.5 million, would eliminate the need for blast furnaces and sinter plants, a constant source of air pollution.

Chrysler Corp. disclosed that early test results of laboratory research indicated that a gasoline additive, ethylene dibromide, and not lead may be primarily responsible for poisoning noble oxidation catalysts. The early results, subject to verification in road tests, indicated that leaded gasoline without ethylene dibromide could be used successfully with platinum-palladium catalysts.

Bureau of Mines investigators at Rolla, Mo., reported significant progress in laboratory research to develop new technology for recovering lead from flotation concentrates to replace present sintering and blast furnace reduction. The new technique, using a vapor phase reduction of lead sulfide, permits recovery of lead metal and elemental sulfur rather than SO_2. A new hydrometallurgical process for recovering lead from scrap batteries that would eliminate SO_2 pollution tested by Bureau metallurgists at College Park, Md. achieved a 98% reduction and a 94% recovery of lead. The process converts $PbSO_4$, Pb_0, and $CaSO_4$ by mixing with a slurry of $Ca(OH)_2$. Continued progress was reported by Bureau metallurgists on developing an aqueous chlorine and electrolytic oxidation leaching process for extracting metals from lead-zinc sulfide concentrates. Extractions in the range of 95% to 99% of the contained lead, zinc, copper, and silver were achieved, and 85% of the sulfide content of the concentrate was converted to elemental sulfur.

Cooperative research by the Naval Research Laboratory (NRL) and ILZRO, in conjunction with battery manufacturers, were directed essentially toward improving battery performance and life. Investigations encompassed the effects of charge and discharge on lead plate microstructure, the causes of capacity loss, and the influence of antimony on the morphology of the lead dioxide.[23]

The joint abstracting service of Lead Industries Association and Lead Development Association afforded researchers a worldwide coverage of new research developments in reports and patents classified under such headings as: analysis, batteries, cables, casting, ceramics, chemicals, coatings, composites, electrochemistry, extraction, health and safety, paints and pigments, physical metallurgy and production.[24]

The Geological Survey issued a comprehensive report on U.S. Mineral Resources which included a review of world lead deposits and reserves.[25]

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[23] Battery Council International, 85th Convention. 1973, pp. 176–183.

[24] Lead Development Association, London and Lead Industries Association, New York. Lead Abstracts. Alden Press, Oxford, England, v. 13, Nos. 1–6, 1973, pp. 1–160.

[25] United States Mineral Resources. Geol. Sur., Prof. Paper 820, 1973, pp. 313–332.

Table 2.—Mine production of recoverable lead in the United States, by State

(Short tons)

State	1969	1970	1971	1972	1973
Alaska	2	--	--	--	6
Arizona	217	285	859	1,763	763
California	2,518	1,772	2,284	1,153	44
Colorado	21,767	21,855	25,746	31,346	28,112
Idaho	65,597	61,211	66,610	61,407	61,744
Illinois	791	1,532	1,238	1,335	541
Kansas	395	80	--	--	--
Maine	--	--	--	85	204
Missouri	355,452	421,764	429,634	489,397	487,143
Montana	1,753	996	615	287	176
Nevada	1,420	364	111	(1)	--
New Mexico	2,368	3,550	2,971	3,582	2,556
New York	1,686	1,280	877	1,089	2,304
Oklahoma	605	797	--	--	--
Oregon	(1)	(1)	--	--	--
South Dakota	1	3	--	--	--
Utah	41,332	45,377	38,270	20,706	13,733
Virginia	3,358	3,356	3,386	3,441	2,637
Washington	8,649	6,784	5,177	2,567	2,217
Wisconsin	1,102	761	752	757	844
Other States	--	--	20	--	--
Total	509,013	571,767	578,550	618,915	603,024

[1] Less than ½ unit.

Table 3.—Production of lead and zinc in the United States in 1973, by State and class of ore, from old tailings, etc., in terms of recoverable metal

(Short tons)

State	Lead ore			Zinc ore			Lead-zinc ore		
	Gross weight (dry basis)	Lead content	Zinc content	Gross weight (dry basis)	Lead content	Zinc content	Gross weight (dry basis)	Lead content	Zinc content
Alaska	12	6	--	--	--	--	--	--	--
Arizona	--	--	--	--	--	--	--	--	--
California	222	34	8	--	--	--	(1)	(1)	(1)
Colorado	692	5	--	224,942	2,600	21,313	471,903	14,752	25,520
Idaho	244,660	26,084	2,045	9,270	9	423	874,256	34,639	42,871
Illinois	--	--	--	(2)	(2)	(2)	--	--	--
Kentucky	--	--	--	--	--	--	--	--	--
Maine	--	--	--	230,172	204	19,640	--	--	--
Missouri	7,585,647	487,143	82,350	--	--	--	--	--	--
Montana	195	11	3	--	--	--	328	13	11
New Jersey	--	--	--	193,402	--	33,027	--	--	--
New Mexico	--	--	--	128,367	2,484	12,035	1,542	68	64
New York	--	--	--	1,093,838	2,304	81,455	--	--	--
Pennsylvania	--	--	--	382,511	--	18,857	--	--	--
Tennessee	--	--	--	2,134,789	--	59,570	--	--	--
Utah	--	--	--	--	--	--	188,311	13,733	16,800
Virginia	--	--	--	577,348	2,637	16,683	--	--	--
Washington	500	5	--	--	--	--	212,289	2,211	6,376
Wisconsin	--	--	--	379,014	844	8,672	--	--	--
Total	7,831,928	513,288	84,406	5,353,653	11,082	271,675	1,748,629	65,416	91,642
Percent of total lead-zinc	--	85	18	--	2	57	--	11	19

See footnotes at end of table.

Table 3.—Production of lead and zinc in the United States in 1973, by State and class of ore, from old tailings, etc., in terms of recoverable metal—Continued

(Short tons)

State	Copper-lead, copper-zinc, and copper-lead-zinc ores			All other sources [3]			Total		
	Gross weight (dry basis)	Lead content	Zinc content	Gross weight (dry basis)	Lead content	Zinc content	Gross weight (dry basis)	Lead content	Zinc content
Alaska	--	--	--	--	--	--	12	6	--
Arizona	93,284	192	8,407	61,571,820	571	20	61,665,104	763	8,427
California	--	--	--	[1] 5,257	[1] 10	[1] 12	5,479	44	20
Colorado	390,354	8,818	10,310	107,502	1,937	1,196	1,195,393	28,112	58,339
Idaho	--	--	--	312,459	1,012	768	1,440,645	61,744	46,107
Illinois	--	--	--	[2] 66,848	[2] 541	[2] 5,250	66,848	541	5,250
Kentucky	--	--	--	--	--	273	--	--	273
Maine	--	--	--	--	--	--	230,172	204	19,640
Missouri	--	--	--	--	--	--	7,585,647	487,143	82,350
Montana	--	--	--	25,686	152	59	26,209	176	73
New Jersey	--	--	--	--	--	--	193,402	--	33,027
New Mexico	--	--	--	2,803,668	4	228	2,933,577	2,556	12,327
New York	--	--	--	--	--	--	1,093,838	2,304	81,455
Pennsylvania	--	--	--	--	--	--	382,511	--	18,857
Tennessee	1,322,930	--	4,602	--	--	--	3,457,719	--	64,172
Utah	--	--	--	--	--	--	188,311	13,733	16,800
Virginia	--	--	--	--	--	--	577,348	2,637	16,683
Washington	--	--	--	61,372	1	2	274,161	2,217	6,378
Wisconsin	--	--	--	--	--	--	379,014	844	8,672
Total	1,806,568	9,010	23,319	64,954,612	4,228	7,808	81,695,390	603,024	478,850
Percent of total lead-zinc	--	1	5	--	1	1	--	100	100

[1] Lead-zinc and ore from "Other sources" combined to avoid disclosing individual company confidential data.

[2] Zinc ore and ore from "Other sources" combined to avoid disclosing individual company confidential data.

[3] Lead and zinc recovered from copper, gold, silver, and fluorspar ores, and from mill tailings and miscellaneous cleanups.

Table 4.—Mine production of recoverable lead in the United States, by month

(Short tons)

Month	1972	1973	Month	1972	1973
January	48,849	53,462	August	56,866	55,662
February	53,302	49,958	September	50,654	51,394
March	55,645	45,302	October	51,625	53,743
April	52,177	40,056	November	46,540	49,006
May	54,093	55,934	December	45,365	53,205
June	51,153	43,907			
July	52,646	51,395	Total	618,915	603,024

Table 5.—Twenty-five leading lead-producing mines in the United States in 1973, in order of output

Rank	Mine	County and State	Operator	Source of lead
1	Buick	Iron, Mo	AMAX Lead Co. of Missouri	Lead ore.
2	Fletcher	Reynolds, Mo	St. Joe Minerals Corp	Do.
3	Magmont	Iron, Mo	Cominco American, Inc	Do.
4	Ozark	Reynolds, Mo	Ozark Lead Co	Do.
5	Viburnum No. 29	Washington, Mo	St. Joe Minerals Corp	Do.
6	Viburnum No. 28	Iron, Mo	do	Do.
7	Bunker Hill	Shoshone, Idaho	The Bunker Hill Co	Lead-zinc ore.
8	Lucky Friday	do	Hecla Mining Co	Lead ore.
9	Burgin	Utah, Utah	Kennecott Copper Corp	Lead-zinc ore.
10	Star Unit	Shoshone, Idaho	Hecla Mining Co	Do.
11	Viburnum No. 27	Crawford, Mo	St. Joe Minerals Corp	Lead ore.
12	Indian Creek No. 32	Washington, Mo	do	Do.
13	Idarado	Ouray and San Miguel, Colo.	Idarado Mining Co	Copper-lead-zinc ore.
14	Leadville	Lake, Colo	American Smelting and Refining Co	Lead-zinc and lead-zinc-copper ores.
15	Indian Creek No. 23	Washington, Mo		
16	Brushy Creek	Reynolds, Mo	St. Joe Minerals Corp	Lead ore.
17	Sunnyside	San Juan, Colo	do	Do.
18	Dayrock	Shoshone, Idaho	Standard Metals Corp	Lead-zinc ore.
19	Silver Star	do	Day Mines, Inc	Lead ore.
20	Camp Bird	Ouray, Colo	do	Do.
21	Austinville and Ivanhoe	Wythe, Va	Federal Resources Corp	Lead-zinc ore.
22	Eagle	Eagle, Colo	The New Jersey Zinc Co	Zinc ore.
			do	Do.
23	Ground Hog	Grant, N. Mex	American Smelting and Refining Company	Do.
24	Balmat	St. Lawrence, N.Y.	St. Joe Minerals Corp	Do.
25	Pend Oreille	Pend Oreille, Wash	Pend Oreille Mines and Metals Co.	Lead-zinc ore.

Table 6.—Refined lead produced at primary refineries in the United States, by source material

(Short tons)

	1969	1970	1971	1972 r	1973
Refined lead: [1]					
From primary sources:					
Domestic ores and base bullion	513,931	528,086	573,022	r 577,398	567,256
Foreign ores and base bullion	124,724	138,644	76,993	103,001	107,260
Total	638,655	666,730	650,015	r 680,399	674,516
From secondary sources	4,966	4,367	1,223	1,189	--
Grand total	643,621	671,097	651,238	r 681,588	674,516
Calculated value of primary refined lead (thousands) [2]	$190,702	$209,220	$180,574	r $204,528	$219,757

r Revised.

[1] GSA metal is not included in refined lead production.

[2] Value based on average quoted price and excludes value of refined lead produced from scrap at primary refineries.

Table 7.—Antimonial lead produced at primary lead refineries in the United States

Year	Production (short tons)	Antimony content: Short tons	Antimony content: Percent	Lead content by difference (short tons): From domestic ore	From foreign ore	From scrap	Total
1969	24,741	2,082	8.4	11,507	4,743	6,409	22,659
1970	20,438	1,184	5.8	8,826	2,829	7,599	19,254
1971	19,686	1,191	6.0	12,247	3,869	2,379	18,495
1972	15,051	1,050	7.0	6,136	2,049	5,816	14,001
1973	15,455	1,167	7.5	9,020	4,203	1,065	14,288

Table 8.—Stocks and consumption of new and old lead scrap in the United States in 1973

(Short tons, gross weight)

Class of consumers and type of scrap	Stocks Jan. 1 r	Receipts	Consumption			Stocks Dec. 31
			New scrap	Old scrap	Total	
Smelters and refiners:						
Soft lead	2,382	35,904	--	36,279	36,279	2,007
Hard lead	758	51,890	--	51,992	51,992	656
Cable lead	1,629	26,603	--	26,897	26,897	1,335
Battery-lead plates	39,300	559,363	--	544,438	544,438	54,225
Mixed common babbitt	302	6,696	--	6,564	6,564	434
Solder and tinny lead	453	12,728	--	11,991	11,991	1,190
Type metals	2,392	27,766	--	27,950	27,950	2,208
Drosses and residues	19,018	157,663	154,682	--	154,682	21,999
Total	66,234	878,613	154,682	706,111	860,793	84,054
Foundries and other manufacturers:						
Soft lead	--	--	--	--	--	--
Hard lead	--	--	--	--	--	--
Cable lead	--	--	--	--	--	--
Battery-lead plates	--	--	--	--	--	--
Mixed common babbitt	17	7,192	--	6,970	6,970	239
Solder and tinny lead	--	--	--	--	--	--
Type metals	--	--	--	--	--	--
Drosses and residues	--	--	--	--	--	--
Total	17	7,192	--	6,970	6,970	239
All consumers:						
Soft lead	2,382	35,904	--	36,279	36,279	2,007
Hard lead	758	51,890	--	51,992	51,992	656
Cable lead	1,629	26,603	--	26,897	26,897	1,335
Battery-lead plates	39,300	559,363	--	544,438	544,438	54,225
Mixed common babbitt	319	13,888	--	13,534	13,534	673
Solder and tinny lead	453	12,728	--	11,991	11,991	1,190
Type metals	2,392	27,766	--	27,950	27,950	2,208
Drosses and residues	19,018	157,663	154,682	--	154,682	21,999
Grand total	66,251	885,805	154,682	713,081	867,763	84,293

r Revised.

Table 9.—Secondary metal recovered [1] from lead and tin scrap in the United States in 1973, by type of product

(Short tons)

	Lead	Tin	Antimony	Other	Total
Refined pig lead	149,215	--	--	--	149,215
Remelt lead	36,909	--	--	--	36,909
Total	186,124	--	--	--	186,124
Refined pig tin	--	1,806	--	--	1,806
Remelt tin	--	307	--	--	307
Total	--	2,113	--	--	2,113
Lead and tin alloys:					
Antimonial lead	375,778	1,062	19,212	698	396,750
Common babbitt	13,003	680	1,374	2	15,059
Genuine babbitt	34	161	8	3	206
Solder	29,088	6,147	776	65	36,076
Type metals	22,878	1,178	2,629	4	26,689
Cable lead	10,544	--	52	4	10,600
Miscellaneous alloys	596	79	11	60	746
Total	451,921	9,307	24,062	836	486,126
Tin content of chemical products	--	955	--	--	955
Grand total	638,045	12,375	24,062	836	675,318

[1] Most of the figures herein represent actual reported recovery of metal from scrap.

Table 10.—Secondary lead recovered in the United States

(Short tons)

	1969	1970	1971	1972	1973
As metal:					
At primary plants	4,966	4,367	1,223	1,189	--
At other plants	149,344	154,800	148,911	172,168	186,124
Total	154,310	159,167	150,134	173,357	186,124
In antimonial lead:					
At primary plants	6,409	7,599	2,379	5,816	1,065
At other plants	336,066	340,759	340,333	340,066	374,713
Total	342,475	348,358	342,712	345,882	375,778
In other alloys	107,120	89,865	103,951	97,358	92,384
Grand total:					
Quantity	603,905	597,390	596,797	616,597	654,286
Value (thousands)	$180,326	$187,461	$165,790	$185,349	$213,166

Table 11.—Lead recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1972	1973	Form of recovery	1972	1973
New scrap:			As soft lead:		
Lead-base	113,795	110,787	At primary plants	1,189	--
Copper-base	4,669	4,506	At other plants	172,168	186,124
Tin-base	421	403	Total	173,357	186,124
Total	118,885	115,696			
Old scrap:			In antimonial lead [1]	345,882	375,778
Battery-lead plates	347,881	369,819	In other lead alloys	82,725	75,545
All other lead-base	134,209	153,938	In copper-base alloys	14,614	16,805
Copper-base	15,620	14,831	In tin-base alloys	19	34
Tin-base	2	2	Total	443,240	468,162
Total	497,712	538,590	Grand total	616,597	654,286
Grand total	616,597	654,286			

[1] Includes 5,816 tons of lead recovered in antimonial lead from secondary sources at primary plants in 1972 and 1,065 in 1973.

Table 12.—Lead consumption in the United States, by product

(Short tons)

Product	1972	1973	Product	1972	1973
Metal products:			Pigments—Continued:		
Ammunition	84,699	81,479	Pigment colors	16,264	16,963
Bearing metals	15,915	15,657	Other [1]	337	477
Brass and bronze	19,805	22,735	Total	89,214	108,766
Cable covering	45,930	43,005			
Calking lead	22,483	20,057	Chemicals:		
Casting metals	7,139	7,220	Gasoline antiknock		
Collapsible tubes	4,020	2,860	additives	278,340	274,410
Foil	4,592	4,985	Miscellaneous		
Pipes, traps, bends	17,780	21,291	chemicals	849	944
Sheet lead	23,667	23,394	Total	279,189	275,354
Solder	71,289	71,770			
Storage batteries:			Miscellaneous uses:		
Battery grids,			Annealing	4,329	3,974
posts, etc	347,225	365,557	Galvanizing	1,397	1,294
Battery oxides	379,367	403,890	Lead plating	638	744
Terne metal	504	2,658	Weights and ballast	21,302	20,848
Type metal	19,944	21,922	Total	27,666	26,860
Total	1,064,359	1,108,480	Other, unclassified uses	24,826	21,749
Pigments:			Grand total [2]	1,485,254	1,541,209
White lead	2,814	1,749			
Red lead and					
litharge	69,799	89,577			

[1] Includes lead content of leaded zinc oxide and other pigments.
[2] Includes lead which went directly from scrap to fabricated products.

Table 13.—Lead consumption in the United States, by month

(Short tons)

Month	1972	1973	Month	1972	1973
January	122,272	135,308	August	127,368	125,707
February	123,671	131,695	September	125,984	124,793
March	132,311	143,197	October	132,241	140,655
April	122,367	128,432	November	131,438	131,420
May	129,012	128,776	December	120,500	120,208
June	126,651	129,124	Total [1]	1,485,254	1,541,209
July	91,439	101,894			

[1] Includes lead which went directly from scrap to fabricated products and lead contained in leaded zinc oxide and other pigments.

Table 14.—Lead consumption in the United States in 1973, by class of product and type of material

(Short tons)

Product	Soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
Metal products	184,141	70,425	68,228	16,239	339,033
Storage batteries	415,471	353,976	--	--	769,447
Pigments	108,766	--	--	--	108,766
Chemicals	275,026	328	--	--	275,354
Miscellaneous	12,208	14,604	48	--	26,860
Unclassified	19,750	1,188	811	--	21,749
Total	1,015,362	440,521	69,087	16,239	[1] 1,541,209

[1] Includes lead that went directly from scrap to fabricated products, and lead contained in leaded zinc oxide and other pigments.

Table 15.—Lead consumption in the United States in 1973, by State [1]

(Short tons)

State	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
California	87,559	41,223	5,453	799	135,034
Colorado	1,259	1,145	79	--	2,483
Connecticut	10,959	9,500	--	1,496	21,955
District of Columbia	118	--	--	--	118
Florida	4,806	8,929	--	--	13,735
Georgia	61,197	25,671	338	--	87,206
Illinois	96,295	44,303	11,001	1,610	153,209
Indiana	116,641	51,035	3,638	466	171,780
Kansas	12,092	10,279	43	133	22,547
Kentucky	7,673	13,595	2	--	21,270
Maryland	1,060	8,526	2,883	7	12,476
Massachusetts	2,884	684	20	294	3,882
Michigan	13,571	21,321	2,785	67	37,744
Missouri	30,047	9,855	2,014	1,093	43,009
Nebraska	3,428	988	1,524	1,636	7,576
New Jersey	129,780	15,467	7,427	718	153,392
New York	48,984	3,414	11,532	458	64,388
Ohio	12,715	4,543	8,067	2,395	27,720
Pennsylvania	65,413	51,211	4,950	2,573	124,147
Rhode Island	3,866	335	--	--	4,201
Tennessee	1,413	17,530	207	133	19,283
Virginia	663	2,653	1,031	681	5,028
Washington	17,816	910	1	--	18,727
West Virginia	20,119	432	--	--	20,551
Wisconsin	6,361	9,832	23	432	16,648
Alabama and Mississippi	6,123	7,169	--	463	13,755
Arkansas and Oklahoma	5,806	3,600	85	--	9,491
Hawaii and Oregon	4,081	6,959	--	--	11,040
Iowa and Minnesota	6,636	12,722	3,750	141	23,249
Louisiana and Texas	216,419	38,391	1,556	471	256,837
Montana and Idaho	842	--	--	--	842
New Hampshire, Maine, Vermont, Delaware	8,635	11,223	678	173	20,709
North and South Carolina	10,068	7,076	--	--	17,144
Utah, Nevada, Arizona	33	--	--	--	33
Total	1,015,362	440,521	69,087	16,239	1,541,209

[1] Includes lead that went directly from scrap to fabricated products and lead contained in leaded zinc oxide and other pigments.

Table 16.—Production and shipments of lead pigments[1] and oxides in the United States

Product	1972				1973			
	Production (short tons)	Shipments			Production (short tons)	Shipments		
		Short tons	Value[2]			Short tons	Value[2]	
			Total	Average per ton			Total	Average per ton
White lead:								
Dry	7,811	9,728	$4,466,278	$459	7,103	9,544	$4,906,724	$514
In oil[3]	304	338	230,201	681	--	--	--	--
Total	8,115	10,066	4,696,479	467	7,103	9,544	4,906,724	514
Red lead	24,168	19,773	7,266,019	367	17,339	16,023	6,300,051	393
Litharge	139,800	147,622	49,160,732	333	175,167	179,144	61,729,436	345
Black oxide	306,689	--	--	--	342,283	--	--	--

[1] Excludes basic lead sulfate, figures withheld to avoid disclosing individual company confidential data.
[2] At plant, exclusive of container.
[3] Weight of white lead only, but value of paste.

Table 17.—Lead content of lead and zinc pigments[1] and lead oxides produced by domestic manufacturers, by source

(Short tons)

Product	1972				1973			
	Lead in pigments produced from—			Total lead in pigments	Lead in pigments produced from—			Total lead in pigments
	Ore		Pig lead		Ore		Pig lead	
	Domestic	Foreign			Domestic	Foreign		
White lead	--	--	6,492	6,492	--	--	5,682	5,682
Red lead	--	--	21,908	21,908	--	--	15,718	15,718
Litharge	--	--	130,014	130,014	--	--	162,905	162,905
Black oxide	--	--	292,492	292,492	--	--	326,580	326,580
Leaded zinc oxide	W	W	--	W	W	W	--	W
Total	W	W	450,906	450,906	W	W	510,885	510,885

W Withheld to avoid disclosing individual company confidential data.
[1] Excluding lead in basic lead sulfate.

Table 18.—Distribution of white lead (dry and in oil) shipments,[1] by industry

(Short tons)

Industry	1969	1970	1971	1972	1973
Paints	5,969	4,460	4,396	6,768	3,198
Ceramics	67	26	34	31	18
Other	4,323	4,152	2,351	3,267	6,328
Total	10,359	8,638	6,781	10,066	9,544

[1] Excludes basic lead sulfate, figures withheld to avoid disclosing individual company confidential data.

Table 19.—Distribution of red lead shipments, by industry

(Short tons)

Industry	1969	1970	1971	1972	1973
Paints	9,191	7,848	8,717	4,909	6,509
Storage batteries	9,302	W	W	W	W
Other	3,684	11,596	12,272	14,864	9,514
Total	22,177	19,444	20,989	19,773	16,023

W Withheld to avoid disclosing individual company confidential data; included with "Other."

Table 20.—Distribution of litharge shipments, by industry

(Short tons)

Industry	1969	1970	1971	1972	1973
Ceramics	21,570	24,578	24,337	23,188	35,910
Insecticides	W	W	W	W	W
Oil refining	1,603	2,016	1,413	1,262	620
Paints	1,511	1,315	3,085	7,316	3,112
Rubber	1,794	1,663	2,081	2,162	5,078
Other	109,241	116,771	116,928	113,694	134,424
Total	135,719	146,343	147,844	147,622	179,144

W Withheld to avoid disclosing individual company confidential data; included with "Other."

Table 21.—U.S. imports for consumption of lead pigments and compounds

Kind	1972		1973	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
White lead	600	$216	401	$268
Red lead	1,289	377	593	188
Litharge	15,358	4,147	14,318	4,840
Chrome yellow	7,530	3,809	4,492	2,972
Other lead pigments	1,348	490	357	139
Other lead compounds	425	205	354	195
Total	26,550	9,244	20,515	8,602

Table 22.—Stocks of lead at primary smelters and refineries in the United States, Dec. 31

(Short tons)

Stocks	1969	1970	1971	1972	1973
Refined pig lead	21,283	90,866	46,762	60,840	22,018
Lead in antimonial lead	4,448	6,988	5,318	3,626	4,062
Lead in base bullion	12,726	11,710	13,803	11,514	8,845
Lead in ore and matte	63,403	83,421	55,777	69,593	54,922
Total	101,860	192,985	121,660	145,573	89,847

Table 23.—Consumer stocks of lead in the United States, Dec. 31, by type of material

(Short tons, lead content)

Year	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
1969	67,304	49,649	8,506	945	126,404
1970	82,823	42,420	7,344	915	133,502
1971	81,934	35,700	6,979	964	125,577
1972	74,161	36,157	6,977	1,249	118,544
1973	84,274	32,226	6,954	667	124,121

Table 24.—Average monthly and yearly quoted prices of lead[1]

(Cents per pound)

Month	1972 U.S. producer	1972 London Metal Exchange	1973 U.S. producer	1973 London Metal Exchange
January	14.00	11.40	14.82	14.42
February	14.60	13.33	15.39	15.41
March	15.50	14.51	16.00	16.87
April	15.57	14.32	16.02	17.54
May	15.60	14.40	16.48	17.96
June	15.50	14.10	16.50	19.27
July	15.50	13.77	16.50	21.28
August	15.41	13.50	16.50	19.85
September	15.00	13.71	16.50	20.14
October	14.67	13.46	16.50	21.36
November	14.50	13.48	16.50	22.13
December	14.50	13.98	17.72	26.84
Average	15.03	13.68	16.29	19.47

[1] Metals Week. Quotations for United States on a nationwide, delivered basis.

Table 25.—U.S. exports of lead, by country[1]

Destination	1972 Quantity (short tons)	1972 Value (thousands)	1973 Quantity (short tons)	1973 Value (thousands)
Unwrought lead and lead alloys:				
Belgium-Luxembourg	755	$314	1,632	$702
Brazil	28	7	8,681	2,744
Canada	553	265	1,177	442
Dominican Republic	14	6	24	15
Germany, West	4	1	554	214
Greece	--	--	1,102	60
Honduras	56	25	58	28
Hong Kong	21	16	119	35
Italy	3,203	897	5,791	2,157
Jamaica	5	2	8	5
Japan	30	24	22,169	9,222
Korea, Republic of	1	3	1,801	616
Mexico	338	115	878	356
Netherlands	958	426	5,849	2,064
Philippines	35	54	57	46
Portugal	--	--	208	100
Singapore	--	--	71	26
Spain	106	11	35	14
Switzerland	--	--	220	71
Taiwan	20	18	170	61
Turkey	--	--	788	310
United Kingdom	34	18	270	109
Venezuela	306	179	107	40
Other	138	79	92	65
Total	6,605	2,460	51,861	19,502
Wrought lead and lead alloys:				
Australia	28	36	27	64
Belgium-Luxembourg	25	24	1,213	458
Brazil	11	6	66	31
Canada	282	246	459	624
Colombia	13	8	13	50
Denmark	19	17	278	24
Dominican Republic	39	58	75	167
Ecuador	6	5	36	20
France	37	42	30	44
Germany, West	14	16	39	43
Hong Kong	19	16	114	49
Italy	42	34	4,469	1,531
Jamaica	27	28	17	11
Japan	114	130	869	502
Korea, Republic of	--	--	539	353
Mexico	102	106	588	595
Netherlands	301	584	5,279	2,203
Panama	28	31	73	84
South Vietnam	1	1	41	24
Sweden	67	59	37	31
Taiwan	51	62	52	38

See footnotes at end of table.

Table 25.—U.S. exports of lead, by country [1]—Continued

Destination	1972 Quantity (short tons)	1972 Value (thousands)	1973 Quantity (short tons)	1973 Value (thousands)
Wrought lead and alloys—Continued				
United Kingdom	131	$99	117	$173
Venezuela	125	105	42	175
Other	289	327	242	301
Total	1,771	2,040	14,715	7,595
Scrap:				
Belgium-Luxembourg	193	41	55	5
Brazil	445	69	5,327	1,149
Canada	27,123	2,828	23,186	3,033
Denmark	56	7	422	120
Germany, West	1,809	200	3,189	725
Hong Kong	--	--	40	14
Italy	42	11	1,575	511
Japan	1,474	256	9,526	3,010
Korea, Republic of	--	--	3,381	828
Mexico	--	--	37	16
Netherlands	2,441	579	3,550	847
Pacific Islands, Trust Territories of the	--	--	45	20
Pakistan	--	--	55	49
South Africa, Republic of	109	19	293	48
Spain	--	--	1,036	260
Sweden	--	--	448	79
Taiwan	--	--	4,045	682
Turkey	--	--	790	138
United Kingdom	220	61	450	170
Venezuela	1,205	180	2,420	522
Other	116	13	3	1
Total	35,233	4,264	59,873	12,227
Grand total	43,609	8,764	126,449	39,324

[1] In addition, foreign lead was reexported as follows: 1972, none; 1973, 3,410 tons ($1,801,316). Wrought lead and lead alloys 1972, 3 tons ($12,943): scrap 251 tons ($25,054 revised); 1973, 6 tons ($35,295); scrap 103 tons ($13,441).

Table 26.—U.S. exports of lead, by class

Year	Blocks, pigs, anodes, etc.				Wrought lead and lead alloys				Scrap	
	Unwrought		Unwrought alloys		Sheets, plates, rods and other forms		Foil, powder, flakes			
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1971	2,611	$777	1,158	$618	1,582	$1,369	574	$1,125	17,091	$2,268
1972	5,134	1,741	1,471	719	1,375	1,312	396	728	35,233	4,264
1973	46,778	17,538	5,083	1,964	14,160	7,010	555	585	59,873	12,227

Table 27.—U.S. imports[1] of lead, by country

Country	1971 Quantity (short tons)	1971 Value (thousands)	1972 Quantity (short tons)	1972 Value (thousands)	1973 Quantity (short tons)	1973 Value (thousands)
Ore, flue dust, matte (lead content):						
Argentina	227	$42	9	$2	--	--
Australia	8,893	1,656	20,722	4,350	21,728	$5,257
Canada	21,885	4,217	30,338	6,370	18,063	3,733
Colombia	211	42	216	48	223	54
Guatemala	1,075	93	--	--	--	--
Honduras	15,121	1,543	17,790	2,543	20,254	4,229
Japan	--	--	--	--	14,310	2,576
Mexico	146	27	1,181	199	1,791	541
Nicaragua	--	--	3,329	537	1,934	489
Peru	18,393	3,579	27,820	6,021	24,033	5,779
Other	47	53	109	24	147	11
Total	65,998	11,252	101,514	20,094	102,483	22,669
Base bullion (lead content):						
Canada	--	--	895	238	4	1
Mexico	14	4	--	--	--	--
United Kingdom	27	12	--	--	--	--
Total	41	16	895	238	4	1
Pigs and bars (lead content):						
Australia	46,044	10,107	35,638	8,677	45,550	12,274
Belgium-Luxembourg	153	100	2,903	822	27	60
Burma	--	--	186	46	--	--
Canada	56,821	14,015	82,816	22,234	61,906	18,940
Denmark	281	119	843	331	242	125
France	--	--	123	45	(2)	6
Germany:						
East	--	--	1,102	265	--	--
West	173	411	1,445	513	115	236
Mexico	29,645	6,725	35,513	8,069	20,388	5,690
Netherlands	198	75	2,292	693	275	343
Peru	36,372	9,500	49,260	13,320	42,772	12,948
South Africa, Republic of	13,519	4,083	8,804	2,698	5,644	1,718
Sweden	--	--	27	22	43	21
Switzerland	--	--	7,994	2,067	--	--
United Kingdom	3,677	1,227	11,777	3,160	1,121	561
Yugoslavia	8,704	2,258	1,651	460	--	--
Other	--	--	16	23	13	7
Total	195,587	48,620	242,390	63,445	178,096	52,929
Reclaimed scrap, etc. (lead content):						
Australia	1,741	423	2,472	559	1,646	346
Austria	100	27	--	--	--	--
Bahamas	1	1	32	4	28	3
Canada	889	228	356	101	183	28
Dominican Republic	--	--	42	11	18	3
Mexico	642	85	282	42	741	103
Netherlands	--	--	--	--	61	23
Panama	--	--	--	--	13	10
United Kingdom	--	--	51	19	--	--
Other	10	1	--	--	2	(2)
Total	3,383	765	3,235	736	2,692	516
Grand total	265,009	60,653	348,034	84,513	283,275	76,115

[1] Data are "general imports"; that is, they include lead imported for immediate consumption plus material entering the country under bond.
[2] Less than ½ unit.

Table 28.—U.S. imports for consumption[1] of lead, by country

Country	1971 Quantity (short tons)	1971 Value (thousands)	1972 Quantity (short tons)	1972 Value (thousands)	1973 Quantity (short tons)	1973 Value (thousands)
Ore, flue dust, matte (lead content):						
Argentina	290	$57	27	$7	50	$10
Australia	11,382	2,538	12,887	3,150	25,897	5,208
Bolivia	9	(2)	--	--	583	108
Brazil	--	--	--	--	372	67
Canada	36,406	8,209	14,794	3,263	12,017	2,309
Colombia	227	43	234	41	--	--
Honduras	18,803	3,798	8,300	1,213	21,780	2,785
Ireland	--	--	--	--	129	10
Mexico	385	57	3,432	270	559	108
Morocco	42	14	41	9	--	--
Nicaragua	--	--	--	--	424	87
Peru	20,634	4,607	11,910	2,596	32,535	6,715
Other	6	39	17	5	9	2
Total	88,184	19,362	51,642	10,554	94,355	17,409
Base bullion (lead content):						
Canada	--	--	895	238	4	1
Mexico	14	4	--	--	--	--
United Kingdom	27	12	--	--	--	--
Total	41	16	895	238	4	1
Pigs and bars (lead content):						
Australia	43,045	9,512	38,637	9,272	45,550	12,274
Belgium-Luxembourg	153	100	2,903	822	27	60
Burma	--	--	186	46	--	--
Canada	56,820	14,015	83,008	22,285	61,906	18,940
Denmark	281	119	843	331	242	125
France	--	--	123	45	(2)	6
Germany:						
East	--	--	1,102	265	--	--
West	173	411	1,445	513	114	234
Mexico	29,645	6,725	35,513	8,069	20,388	5,690
Netherlands	198	75	2,292	693	275	343
Peru	36,372	9,500	49,260	13,320	42,772	12,948
South Africa, Republic of	13,519	4,083	8,804	2,698	5,644	1,718
Sweden	--	--	27	22	43	21
Switzerland	--	--	7,994	2,067	--	--
United Kingdom	3,660	1,223	11,794	3,165	1,121	561
Yugoslavia	8,704	2,258	1,651	460	--	--
Other	--	--	16	23	13	7
Total	192,570	48,021	245,598	64,096	178,095	52,927
Reclaimed scrap, etc. (lead content):						
Australia	976	264	990	273	1,699	352
Bahamas	1	1	32	4	28	3
Canada	889	228	356	101	183	28
Dominican Republic	--	--	42	11	18	3
Mexico	642	85	282	42	741	103
Netherlands	--	--	--	--	61	23
Panama	--	--	51	19	13	10
United Kingdom	--	--	--	--	--	--
Other	10	1	--	--	2	(2)
Total	2,518	579	1,753	450	2,745	522
Sheets, pipe, and shot:						
Belgium-Luxembourg	20	7	25	10	18	10
Canada	82	37	r 29	r 13	8	3
Germany, West	r 1	r 2	--	--	1	1
Japan	--	--	--	--	(2)	(2)
Netherlands	73	23	r 43	r 15	11	4
South Africa, Republic of	--	--	15	7	--	--
United Kingdom	62	18	r 37	r 16	--	--
Yugoslavia	--	--	30	8	--	--
Total	r 238	r 87	r 179	r 69	38	18
Grand Total	r 283,551	r 68,065	r 300,067	r 75,407	275,237	70,877

r Revised.
[1] Excludes imports for refining, classified as "imports for consumption" by the Bureau of the Census.
[2] Less than ½ unit.

Table 29.—U.S. imports for consumption of lead, by class[1]

(Thousand short tons and thousand dollars)

Year	Lead in ore flue dust or fume, and matte, n.s.p.f (lead content)		Lead in base bullion (lead content)		Pigs and bars (lead content)		Reclaimed scrap, etc. (lead content)		Sheets, pipe and shot		Not otherwise specified (value)	Total value
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value		
1971	88	19,362	(2)	16	193	48,021	3	579	(2)	r 87	r 305	r 68,370
1972	52	10,554	1	238	246	64,096	2	450	(2)	r 69	r 316	r 75,723
1973	94	17,409	(2)	1	178	52,927	3	522	(2)	18	285	71,162

r Revised.
[1] Excludes imports for refining and export, classified as "imports for consumption" by the Bureau of the Census.
[2] Less than ½ unit.

Table 30.—U.S. imports for consumption of miscellaneous products containing lead

Year	Babbitt metal, solder, white metal, and other combinations containing lead		
	Gross weight (short tons)	Lead content	Value (thousands)
1971	1,497	570	$4,433
1972	1,197	464	3,354
1973	1,440	533	4,780

Table 31.—Lead: World mine production by country

(Short tons)

Country[1]	1971	1972	1973 p
North America:			
Canada	433,168	407,887	427,441
Guatemala	r 551	152	112
Honduras	19,805	22,844	21,160
Mexico[2]	172,900	177,866	197,640
Nicaragua	634	4,719	3,000
United States[3]	578,550	618,915	603,024
South America:			
Argentina	r 43,969	41,577	39,700
Bolivia	25,491	22,602	23,131
Brazil	r 30,684	27,565	29,531
Chile	r 971	509	282
Colombia	226	324	169
Peru[4]	r 182,778	208,333	218,883
Europe:			
Austria[3]	8,504	7,350	6,767
Bulgaria	110,000	e 110,000	e 110,000
Czechoslovakia e	r 6,400	r 6,200	6,600
Finland	5,224	4,243	2,500
France	r 32,816	29,343	27,600
Germany, East e	r 11,000	r 7,700	7,700
Germany, West	45,306	42,393	38,025
Greece	r 11,540	17,607	20,700
Greenland	--	--	9,259
Hungary e	1,910	r 2,610	2,800
Ireland	r 56,870	65,600	61,900
Italy	34,833	37,148	30,000
Norway	r 3,376	3,455	3,334
Poland	r 69,200	75,000	77,000
Portugal	1,524	1,275	1,299
Romania e	42,000	42,000	45,000
Spain	77,327	76,548	69,732
Sweden	87,583	83,600	81,700
U.S.S.R. e	r 500,000	510,000	520,000
United Kingdom	r 1,650	440	220
Yugoslavia	137,069	132,468	e 136,700

See footnotes at end of table.

Table 31.—Lead: World mine production by country—Continued

(Short tons)

Country [1]	1971	1972	1973 [p]
Africa:			
Algeria	5,200	5,500	4,300
Congo (Brazzaville)	[r] 32	521	[e] 550
Morocco	85,980	95,460	119,054
Nigeria [e]	237	354	390
South Africa, Republic of	--	151	1,789
South-West Africa, Territory of [5]	[r] 78,813	66,128	68,006
Tunisia	[r] 20,800	20,200	17,635
Zambia (refined)	30,500	28,500	27,571
Asia:			
Burma [e]	9,920	[r] 9,920	11,570
China, People's Republic of [e]	[r] 110,000	[r] 110,000	110,000
India	[r] 1,715	2,798	4,728
Indonesia [e]	220	220	220
Iran [6]	[r] 26,500	35,000	33,000
Japan [7]	77,808	69,946	58,300
Korea, North [e]	88,000	[r] 99,000	105,000
Korea, Republic of	18,236	16,224	14,188
Pakistan [e]	7	[r] ([8])	([8])
Philippines	[r e] 22	--	--
Thailand	[r] 1,624	2,005	[e] 2,200
Turkey	7,260	[r e] 6,860	3,279
Oceania:			
Australia	[r] 444,844	443,753	447,139
New Zealand [9]	1,373	1,273	362
Total	[r] 3,742,950	3,802,086	3,852,190

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition to the countries listed, Uganda and Arab Republic of Egypt may produce lead, but available information is inadequate to make reliable estimates of output levels.

[2] Recoverable metal content of lead in concentrates for export plus lead content of domestic products (refined lead, antimonial lead, mixed bars, and other unspecified items).

[3] Recoverable metal.

[4] Recoverable metal; content of lead in concentrates for exports plus lead content of domestic smelter products (refined lead, antimonial lead, and bismuth-lead bars).

[5] All data for 1971 are for fiscal year ending June 30, 1971; data for 1972 and 1973 are a summation of company figures for calendar year 1972 and 1973 for Tsumeb Corp. Limited and for fiscal year ending June 30, 1972, and June 30, 1973, for South-West Africa Co. Limited, South African Iron and Steel Industrial Corporation Ltd., and Rosh Pinah mine. Output of Tsumeb Corp. Limited for period July 1, 1971, through December 31, 1971 (which is not otherwise covered in table), was 30,590 short tons.

[6] Year beginning March 21 of that stated.

[7] Content of concentrates.

[8] Less than ½ unit.

[9] Contained in lead-copper concentrate.

Table 32.—Lead: World smelter production by country [1]

(Short tons)

Country	1971	1972	1973 p
North America:			
Canada (refined)	2 185,555	205,978	202,500
Guatemala [2]	99	24	72
Mexico (refined)	r 166,968	171,762	190,621
United States (refined) [3]	650,015	688,584	687,739
South America:			
Argentina	r 48,300	43,700	41,700
Bolivia (refined, including solder)	20	e 22	e 22
Brazil	r 28,270	27,594	38,357
Peru (refined)	74,004	94,311	91,361
Europe:			
Austria [4]	10,267	10,777	10,927
Belgium [2]	87,413	102,294	107,696
Bulgaria [2]	112,650	112,440	e 110,000
Czechoslovakia [2]	19,412	20,060	22,000
France	r 117,183	150,061	142,200
Germany, East e	r 28,000	22,000	22,000
Germany, West	108,470	112,440	95,240
Greece (refined)	r 21,830	22,490	22,930
Hungary e 2	790	r 510	550
Italy	r 53,447	55,758	38,639
Netherlands [2]	26,172	24,230	27,840
Poland (refined) [2]	66,400	71,980	71,650
Portugal (refined)	1,300	1,300	1,100
Romania e	40,000	40,000	43,000
Spain	r 112,452	111,052	109,495
Sweden (refined)	r 43,411	52,463	e 55,000
U.S.S.R. (primary) e	r 500,000	510,000	520,000
United Kingdom [5]	42,580	27,615	33,407
Yugoslavia (refined) [2]	109,282	96,448	108,063
Africa:			
Morocco	20,631	--	--
South-West Africa, Territory of (refined) [6]	64,838	70,505	70,098
Tunisia	21,119	7 27,638	7 28,619
Zambia (refined)	30,500	28,500	27,600
Asia:			
Burma	r 9,672	9,294	10,915
China, People's Republic of e	110,000	110,000	110,000
India	1,707	3,020	3,147
Iran e 8	200	r 210	220
Japan (refined) [2]	237,056	246,064	251,366
Korea, North e	r 77,000	r 83,000	88,000
Korea, Republic of	3,456	4,196	4,823
Turkey	3,530	2,650	3,530
Oceania:			
Australia (refined and bullion)	356,731	383,690	408,326
Total	r 3,590,730	3,744,660	3,800,753

e Estimate. p Preliminary. r Revised.
[1] Primary except as noted, or where source does not differentiate.
[2] Includes recovery from secondary materials.
[3] Refined from domestic and foreign ores; excludes lead refined from imported base bullion.
[4] Includes primary lead content of antimonial lead.
[5] Lead bullion from imported ores and concentrates.
[6] Data for 1971 are for years ended June 30, 1971. Data for 1972 and 1973 are for calendar years. Output for the last 6 months of 1971 was 36,506 short tons.
[7] Pig lead only (excludes lead content of antimonial lead).
[8] Year beginning March 21 of year stated.

Lime

By Avery H. Reed[1]

Lime output in 1973 increased 4% to 21.1 million tons, a new annual record. Total value was a record $368.1 million, 8% above 1972.

Other highlights of the year included plans by J. E. Baker Co. to install a gas-cleaning scrubber system at its Millersville, Ohio plant. Black River Mining Co. was doubling its plant at Carntown, Ky., to a total capacity of 700,000 tons per year by late 1975. Colorado Lien Co. planned to build a $3 million lime plant near Buena Vista, Colo.; a vertical kiln will produce quicklime. Dravo Corp. organized a new company, Dravo Lime Co., which planned to construct a 3,000-ton-per-day lime plant near Maysville, Ky.

The Flintkoke Co. planned to replace its 80-ton-per-day limekiln at Nelson, Ariz. with a new 800-ton-per-day, $10 million plant.

A strike at Mississippi Lime Co.'s Missouri plant caused serious shortages of lime in the Midwest. This is the largest limekiln in the country. Rangaire Corp. purchased the Tennessee and Virginia lime plants of Foote Mineral Co.; they will operate as Tennessee Lime Co. and Virginia Lime Co. Southern Industries formed a new company, SI Lime Co., which will operate the Longview plant in Alabama and the Pelican State Lime Co. plant in Louisiana.

Energy.—The Bureau of Mines completed a comprehensive canvass of energy used in the mineral industries in 1973. All lime plants were covered.

The canvass showed that the lime industry depended on the use of coal and natural gas for most of its energy requirements. Only 2% of the total energy was purchased electricity. Total energy used was 39.9 billion kilowatt-hours.

Coal supplied 46% and natural gas 45% of the total energy used, mostly for heat in the calciners. The choice of fuel for individual plants was usually based on geographic proximity to supplies; leading coal-using States were Ohio, Pennsylvania, Missouri, Indiana, and Illinois, which together consumed 69% of the coal; leading natural-gas-using States were Ohio, Texas, Pennsylvania, Michigan, and New York, which together consumed 54% of the natural gas.

The lime industry used 2.6 million tons

[1] Supervisory physical scientist, Division of Nonmetallic Minerals—Mineral Supply.

Table 1.—Salient lime statistics in the United States[1]
(Thousand short tons and thousand dollars)

	1969	1970	1971	1972	1973
Number of plants	201	194	187	185	175
Sold or used by producers:					
Quicklime	15,479	15,248	15,138	16,611	17,230
Hydrated lime	2,864	3,126	3,446	2,604	2,610
Dead-burned dolomite	1,866	1,373	1,007	1,075	1,250
Total	20,209	19,747	19,591	20,290	21,090
Value[2]	280,736	286,155	308,100	339,304	365,849
Average value per ton	13.89	14.49	15.73	16.72	17.35
Lime sold	13,113	12,718	12,337	13,353	14,394
Lime used	7,096	7,029	7,254	6,937	6,696
Exports[3]	51	54	66	38	37
Imports for consumption[3]	184	202	242	248	334

[1] Excludes regenerated lime. Excludes Puerto Rico.
[2] Selling value, f.o.b. plant, excluding cost of containers.
[3] Bureau of the Census.

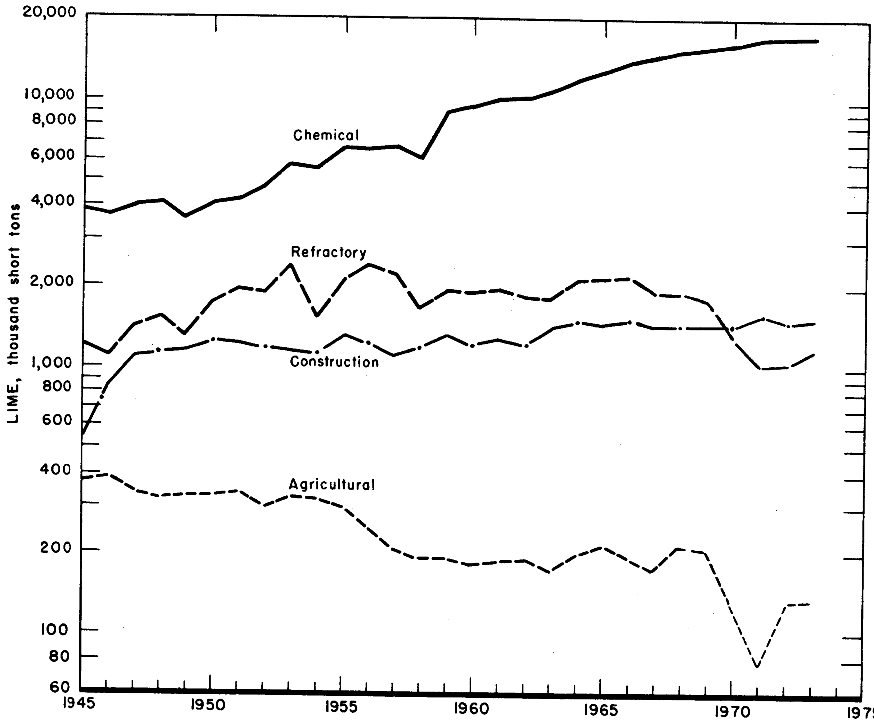

Figure 1.—Trends in major uses of lime.

of coal, 59.6 billion cubic feet of natural gas, 186,000 tons of coke, 848 million kilowatt-hours of purchased electricity, 16.4 million gallons of heavy fuel oil, 9.8 million gallons of diesel oil, 686,000 gallons of gasoline, and 127,000 gallons of propane.

Requirements for each thousand tons of lime produced were 124 tons of bituminous coal, 2.8 million cubic feet of natural gas, 9 tons of coke, 774 gallons of heavy fuel oil, 465 gallons of diesel fuel, 32 gallons of gasoline, and 6 gallons of propane.

Cost of energy used in the lime-manufacturing industry was estimated at $67.8 million, or $3.21 per ton of lime produced. Each ton of lime required 1,890 kilowatt-hours of energy.

Table 2.—Energy used by the lime industry in 1973

(Thousand kilowatt-hours)

Source	Energy used	Percent
Coal	18,530,000	46
Natural gas	18,000,000	45
Coke	1,417,000	3
Electricity	847,900	2
Heavy fuel oil	717,600	2
Diesel fuel	399,700	1
Gasoline	25,110	1
Liquefied petroleum gas	4,876	--
Total energy	[1] 39,930,000	100

[1] Data does not add to total shown because of independent rounding.

Table 3.—Energy materials used by the lime industry in 1973

Source and unit	Quantity
Coal ----------thousand short tons--	2,629
Natural gas ------million cubic feet--	59,587
Coke -----------thousand short tons--	186
Electricity----thousand kilowatt-hours--	847,900
Heavy fuel oil ------thousand gallons--	16,361
Diesel oil ---------------------do----	9,837
Gasoline -----------------------do----	686
Liquefied petroleum gas --------do----	127

Table 4.—Energy materials required by the lime industry in 1973

Source and unit	Quantity
Coal --tons per thousand tons of lime--	124
Natural gas ------cubic feet per ton--	2,820
Coke --tons per thousand tons of lime--	9
Electricity ---kilowatt-hours per ton--	40
Heavy fuel oil gallons per thousand tons--	774
Diesel oil ---------------------do----	465
Gasoline -----------------------do----	32
Liquefied petroleum gas --------do----	6

Table 5.—Cost of energy used in the lime industry in 1973

Source	Total energy cost	Cost per thousand kilowatt-hours	Cost per short ton	Kilowatt-hours per short ton
Coal	$26,290,000	$0.65	$1.24	876
Natural gas	20,860,000	.52	.99	851
Coke	9,300,000	.23	.44	67
Electricity	8,479,000	.21	.40	40
Heavy fuel oil	1,636,000	.4	.8	34
Diesel oil	983,700	.2	.5	19
Gasoline	240,100	.1	.1	1
Liquefied petroleum gas	63,500	--	--	--
Total [1]	67,850,000	1.69	3.21	1,890

[1] Data may not add to totals shown because of independent rounding.

DOMESTIC PRODUCTION

Lime producers sold or used 21.1 million tons, compared with 20.3 million tons in 1972. Sales of lime increased 8% to 14.4 million tons for a new annual record. Captive lime used by producers decreased 4% and was 8% below the 1971 record. Output of refractory dolomite increased 16% but was 48% below the 1956 record. The number of plants decreased from 186 to 176, and the average output per plant increased from 109,300 tons per year to 120,100 tons.

Five States, Ohio, Pennsylvania, Texas, Missouri, and Michigan, accounted for 54% of the total output.

Leading producing companies were Marblehead Lime Co. with four plants in Illinois, one in Indiana, and one each in Michigan, Pennsylvania, and Missouri; Mississippi Lime Co. in Missouri; Allied Chemical Corp. in New York and Louisiana; Bethlehem Steel Corp. with two plants in Pennsylvania and one in New York; Martin-Marietta Chemicals in Ohio and Alabama; Pfizer, Inc., in Ohio, Massachusetts, California, and Connecticut; Warner Co. with two plants in Pennsylvania; United States Gypsum Co. with two plants in Texas and one each in Ohio and Louisiana; Diamond Shamrock Chemical Co. in Ohio; and United States Steel Corp. in Ohio. These 10 companies, operating 28 plants, accounted for 42% of the total lime production.

The 12 largest lime plants, each producing more than 400,000 tons per year, accounted for 32% of the total production. There were 39 plants which produced more than 200,000 tons per year and accounted for 67% of the total output.

Leading individual plants were Mississippi Lime's Ste. Genevieve plant, Marblehead's Buffington plant, Allied Chemical Corp.'s Syracuse plant, Bethlehem's Annville plant, and Diamond Shamrock's Painesville plant.

Table 6.—Lime sold or used by producers in the United States by State and kind [1]

(Thousand short tons and thousand dollars)

State	1972				1973			
	Hydrated	Quick-lime	Total [2]	Value	Hydrated	Quick-lime	Total [2]	Value
Alabama	136	603	739	11,751	140	741	881	14,050
Arizona	W	W	356	6,024	W	W	365	7,019
Arkansas	W	W	150	2,456	W	W	177	2,742
California	66	542	608	13,059	57	575	632	13,602
Colorado	W	W	187	4,070	7	172	178	3,371
Florida	W	W	180	3,527	W	W	187	4,026
Hawaii	W	W	7	266	W	W	6	238
Kansas	--	9	9	172	--	10	10	199
Louisiana	W	W	908	19,614	W	W	897	16,801
Maryland	5	11	17	W	W	W	W	W
Michigan	W	W	1,509	22,753	--	1,545	1,545	26,055
Missouri	W	W	W	W	254	1,373	1,626	23,534
Montana	--	242	242	3,003	--	210	210	3,028
Nebraska	--	34	34	685	--	31	31	651
New Mexico	--	28	28	W	--	44	44	793
Ohio	243	4,171	4,413	75,569	227	4,163	4,389	77,028
Oregon	W	W	96	2,129	W	W	106	2,552
Pennsylvania	380	1,511	1,891	33,802	399	1,862	2,260	40,949
Puerto Rico	42	W	42	1,776	42	--	42	2,215
South Dakota	W	W	W	W	39	24	63	1,206
Texas	609	1,021	1,631	22,181	655	1,022	1,677	26,887
Utah	W	W	171	4,216	W	W	185	3,804
Virginia	69	690	758	11,739	68	715	782	12,205
Wisconsin	W	W	263	5,009	111	199	310	6,004
Wyoming	--	30	30	W	--	30	30	548
Other States [3]	1,095	8,795	6,064	97,279	653	5,764	4,499	78,556
Total [2]	2,645	17,687	20,332	341,080	2,652	18,480	21,132	368,063

W Withheld to avoid disclosing individual company confidential data; included in "Other States."
[1] Excludes regenerated lime. Includes Puerto Rico.
[2] Data may not add to totals shown because of independent rounding.
[3] Includes Connecticut, Idaho, Illinois, Indiana, Iowa, Kentucky, Massachusetts, Minnesota, Mississippi, Nevada, New Jersey, New York, North Dakota, Oklahoma, Tennessee, Washington, West Virginia, and States indicated by symbol W.

Table 7.—Lime sold or used by producers in the United States, by State and market [1]

(Thousand short tons)

State	1972				1973			
	Plants	Sold	Captive	Total [2]	Plants	Sold	Captive	Total [2]
Alabama	5	W	W	739	5	W	W	881
Arizona	8	222	133	356	8	237	128	365
Arkansas	3	W	W	150	3	W	W	177
California	15	223	385	608	15	243	388	632
Colorado	11	5	182	187	11	7	172	178
Florida	3	W	W	180	3	W	W	187
Hawaii	2	W	W	7	2	W	W	6
Kansas	1	--	9	9	1	--	10	10
Louisiana	4	W	W	908	4	W	W	897
Maryland	1	17	--	17	1	W	W	W
Michigan	10	W	W	1,509	9	W	W	1,545
Missouri	4	W	W	W	4	W	W	1,626
Montana	3	--	242	242	3	--	210	210
Nebraska	5	--	34	34	5	4	27	31
New Mexico	1	--	28	28	1	--	44	44
Ohio	19	2,525	1,888	4,413	19	2,914	1,476	4,389
Oregon	3	W	W	96	3	W	W	106
Pennsylvania	11	W	W	1,891	9	W	W	2,260
Puerto Rico	1	42	--	42	1	42	--	42
South Dakota	2	W	W	W	1	63	--	63
Texas	15	1,061	570	1,631	14	1,090	587	1,677
Utah	5	W	W	171	5	W	W	185
Virginia	7	W	W	758	7	W	W	782
Wisconsin	6	263	--	263	5	310	--	310
Wyoming	3	--	30	30	3	--	30	30
Other States [3]	38	9,028	3,446	6,064	35	9,526	3,624	4,499
Total [2]	186	13,385	6,947	20,332	176	14,436	6,696	21,132

W Withheld to avoid disclosing individual company confidential data; included in "Other States."
[1] Excludes regenerated lime. Includes Puerto Rico.
[2] Data may not add to totals shown because of independent rounding.
[3] Includes Connecticut (1 plant), Idaho (4), Illinois (5), Indiana (1), Iowa (1), Kentucky (1), Massachusetts (2), Minnesota (3), Mississippi (1), Nevada (3), New Jersey (1), New York (2), North Dakota (1), Oklahoma (1), Tennessee (2), Washington (3), West Virginia (2), and States indicated by symbol W.

Table 8.—Lime sold or used by producers in the United States, by size of plant[1]

(Thousand short tons)

Size of plant	1972 Plants	1972 Quantity	1972 Percent of total	1973 Plants	1973 Quantity	1973 Percent of total
Less than 10,000 tons	35	176	1	29	155	1
10,000 to 25,000 tons	33	537	3	31	414	2
25,000 to 50,000 tons	31	1,087	5	26	917	4
50,000 to 100,000 tons	30	2,207	11	27	1,965	9
100,000 to 200,000 tons	21	3,052	15	24	3,572	17
200,000 to 400,000 tons	29	8,508	42	27	7,370	35
More than 400,000 tons	7	4,765	23	12	6,739	32
Total	186	20,332	100	176	21,132	100

[1] Excludes regenerated lime. Includes Puerto Rico.

CONSUMPTION AND USES

Lime was consumed in every State. Leading consuming States were Ohio, Pennsylvania, Michigan, Indiana, Texas, Illinois, and New York. These seven States, each of which consumed more than 1 million tons, accounted for 64% of the total lime consumed.

Leading quicklime-consuming States were Ohio, Pennsylvania, Michigan, Indiana, Illinois, and Texas, each of which consumed more than 1 million tons. These six States accounted for 60% of the quicklime consumed.

Leading hydrate-consuming States were Texas, Pennsylvania, Ohio, Illinois, Louisiana, and California, each of which consumed more than 100,000 tons. These six States accounted for 54% of the hydrate consumed.

Lime sold by producers was used for chemicals, 80%; construction, 11%; refractories, 8%; and agriculture, 1%. Captive lime used by producers was 32% of the total, compared with 34% in 1972 and 37% in 1971.

Leading individual uses were basic oxygen steel furnaces, alkalies, water purification, refractories, and paper, which together accounted for 63% of the total consumption, compared with 62% in 1972.

Lime used in agriculture increased 2%. Lime used for refractory dolomite increased 16%. Construction uses continued to expand, increasing 2%. Lime for chemical and industrial use also continued to expand, increasing 3%.

Table 9.—Lime sold or used by producers in the United States, by use [1]

(Thousand short tons and thousand dollars)

Use	1972				1973			
	Sold	Used	Total [2]	Value	Sold	Used	Total [2]	Value
Agriculture	137	--	137	2,711	140	--	140	2,796
Construction:								
Soil stabilization	884	--	884	17,046	874	4	878	17,705
Mason's lime	W	W	411	7,924	444	62	506	10,216
Finishing lime	W	W	229	4,415	219	--	219	4,422
Other construction uses	60	--	60	1,157	9	--	9	182
Total [2]	W	W	1,586	30,542	1,546	66	1,611	32,525
Chemical and industrial:								
Steel, BOF	4,921	1,126	6,047	98,570	5,612	1,454	7,065	117,138
Alkalies	10	3,222	3,233	52,700	5	2,679	2,683	48,811
Water purification	W	W	1,403	22,870	1,458	10	1,469	23,743
Paper and pulp	W	W	787	12,830	832	75	907	14,809
Sugar refining	41	718	759	12,370	79	696	775	13,937
Steel, open-hearth	W	W	665	10,840	593	82	675	11,074
Steel, electric	W	W	641	10,450	575	65	640	10,474
Copper ore concentration	264	283	548	8,923	275	355	630	10,901
Sewage treatment	334	100	434	7,074	440	12	452	7,239
Aluminum and bauxite	W	W	368	5,998	W	W	390	6,639
Glass	372	--	372	6,064	368	--	368	5,947
Calcium carbide	W	W	357	5,819	W	W	216	3,710
Petrochemicals	W	W	W	W	162	--	162	2,618
Acid mine water neutralization	W	W	49	791	71	3	73	1,202
Precipitated calcium carbonate	W	W	W	W	W	W	70	1,198
Metallurgy, other	W	W	53	868	W	W	69	1,172
Magnesium metal	W	W	W	W	37	15	52	871
Petroleum refining	47	--	47	765	43	--	43	695
Chrome	W	W	W	W	2	40	42	760
Plastics	W	W	W	W	37	--	37	598
Food	W	W	77	1,257	33	--	33	533
Tanning	24	--	24	396	26	--	26	420
Ore concentration, other	W	W	26	424	24	--	24	388
Insecticides	30	--	30	484	24	--	24	388
Oil well drilling	13	--	13	211	13	--	13	210
Fertilizer	9	--	9	146	7	--	7	113
Paint	3	--	3	53	3	--	3	48
Rubber	W	W	3	43	3	--	3	48
Wire drawing	W	W	2	30	W	W	2	34
Silica brick	W	W	2	27	2	--	2	32
Sulfur removal	W	W	1	23	1	--	1	16
Other uses [3]	W	W	1,581	25,759	860	1,060	1,175	20,977
Total	W	W	17,534	285,785	11,585	6,546	18,131	306,743
Refractory dolomite	1,006	69	1,075	22,042	1,166	84	1,250	25,999
Grand total [2]	13,395	6,937	20,332	341,080	14,436	6,696	21,132	368,063

W Withheld to avoid disclosing individual company confidential data; included with "Other uses."
[1] Excludes regenerated lime. Includes Puerto Rico.
[2] Data may not add to totals shown because of independent rounding.
[3] Includes magnesia from sea water, magnesite, coke, lithium, sand-lime brick, explosives, adhesives, manganese (1972), and uses indicated by symbol W.

Table 10.—Destination of shipments of lime sold or used by producers in the United States in 1973, by State [1]

(Short tons)

State	Quicklime	Hydrated lime	Total
Alabama	336,542	76,760	413,302
Alaska	W	W	1,509
Arizona	W	W	319,629
Arkansas	145,374	21,715	167,089
California	765,249	107,179	872,428
Colorado	186,142	23,343	209,485
Connecticut	61,803	17,898	79,701
Delaware	20,263	14,954	35,217
District of Columbia	30,628	5,944	36,572
Florida	299,585	54,248	353,833
Georgia	136,325	24,003	160,328
Hawaii	574	6,649	7,223
Idaho	131,956	4,879	136,835
Illinois	1,049,563	152,729	1,202,292
Indiana	1,655,466	74,137	1,729,603
Iowa	60,709	25,471	86,180
Kansas	43,826	27,517	71,343
Kentucky	330,582	20,113	350,695
Louisiana	809,459	108,840	918,299
Maine	40,914	1,946	42,860
Maryland	460,996	22,087	483,083
Massachusetts	41,585	24,335	65,920
Michigan	1,903,646	41,607	1,945,253
Minnesota	127,180	19,191	146,371
Mississippi	152,344	17,052	169,396
Missouri	180,537	41,079	221,616
Montana	212,735	3,033	215,768
Nebraska	44,670	12,818	57,488
Nevada	55,600	6,706	62,306
New Jersey	60,244	85,980	146,224
New Mexico	90,091	14,509	104,600
New York	978,644	54,167	1,032,811
North Carolina	76,264	33,528	109,792
North Dakota	W	W	41,347
Ohio	3,257,033	167,930	3,424,963
Oklahoma	137,190	67,474	204,664
Oregon	103,138	15,909	119,047
Pennsylvania	2,201,954	253,251	2,455,205
Puerto Rico	--	7,715	7,715
Rhode Island	4,781	3,498	8,279
South Carolina	39,920	9,492	49,412
South Dakota	10,574	24,375	34,949
Tennessee	102,902	52,752	155,654
Texas	1,010,246	637,571	1,647,817
Utah	99,176	23,083	122,259
Virginia	119,682	36,561	156,243
Washington	119,924	22,020	141,944
West Virginia	309,074	17,818	326,892
Wisconsin	119,913	49,139	169,052
Wyoming	30,502	2,985	33,487
Other States [2]	312,683	54,273	4,471
Total United States	18,468,188	2,590,263	21,058,451
Exports:			
Canada	8,281	12,921	21,202
Other countries	3,783	48,930	52,713
Total exports	12,064	61,851	73,915
Grand total	18,480,252	2,652,114	21,132,366

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Excludes regenerated lime. Includes Puerto Rico.
[2] Includes New Hampshire, Vermont, and States indicated by symbol W.

PRICES

The average value of lime sold or used by producers in 1973 was $17.42 per ton, an increase of 4% over the 1972 value of $16.78 per ton.

Values for quicklime sold ranged from $15.69 for chemical lime to $16.20 for agricultural lime, $18.71 for construction, and $20.70 for refractory dolomite, and averaged $16.21 per ton.

Values for hydrated lime sold ranged from $20.33 for construction lime to $21.72 for chemical lime and $22.39 for agricultural lime, and averaged $20.59 per ton.

FOREIGN TRADE

Exports of lime decreased 2% to 36,914 tons and were 46% below the 1968 record. Of the total quantity exported, Canada received 64%, Mexico 12%, and the United Kingdom 10%. The remaining 14% went to 32 countries, listed in order: Jamaica, Surinam, British Bahamas, West Germany, Dominican Republic, Brazil, Panama, New Zealand, Saudi Arabia, Nicaragua, Bermuda, Ethiopia, Australia, Denmark, Austria, Japan, Leeward and Windward Islands, Sweden, Argentina, Honduras, Pacific Trust Islands, Venezuela, Liberia, Antilles, Nigeria, British Honduras, Belgium, Tanzania, Philippines, Chile, Angola, and the Netherlands.

Table 11.—U.S. exports of lime

Year	Quantity (short tons)	Value (thousands)
1971	65,862	$1,971
1972	37,659	1,242
1973	36,914	1,208

Table 12.—U.S. imports for consumption of lime

Year	Hydrated lime		Other lime		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1971	39,807	$618	202,477	$2,690	242,284	$3,308
1972	37,468	724	210,995	3,224	248,463	3,948
1973	47,309	941	286,703	4,302	334,012	5,243

WORLD REVIEW

Lime is produced all over the world, mainly in the heavily industrialized areas. Source materials are plentiful. The United States ranks second in world production, with 18% of the total; foreign production is reviewed in the following paragraphs.

Canada.—Beachville Lime Ltd., a subsidiary of Dominion Foundries and Steel Ltd., purchased the Beachville, Ontario, lime plant of Cyanamid of Canada Ltd.

Germany, West.—West Germany ranked fourth in world lime output, with 10% of the total production.

Japan.—Japan produced 11% of the world's lime, ranking third. Most of the lime was used in steel mills.

Poland.—Poland produced 7% of the world's lime and ranked fifth among the countries.

U.S.S.R.—The U.S.S.R. was the leading lime-producing country in the world, with 20% of the total output.

United Kingdom.—Tilling Construction Services Ltd. installed a new lime plant with two rotary kilns and preheaters at Swinden.

Zambia.—Ndola Lime Co. was building a lime plant, to produce 550 tons of lime per day.

Table 13.—Quicklime and hydrated lime, including dead-burned dolomite: World production by country

(Thousand short tons)

Country [1]	1971	1972	1973 [p]
North America:			
Canada	[r] 1,598	1,730	1,826
Costa Rica	12	13	14
Guatemala [e]	25	25	25
Jamaica	151	183	241
Nicaragua [e]	100	100	100
Puerto Rico	44	42	42
United States (sold or used by producers)	19,591	20,290	21,090
South America:			
Brazil [e]	2,200	2,200	2,200
Colombia [e]	1,100	1,100	1,100
Paraguay	26	27	28
Peru [e]	11	11	11
Uruguay	53	[e] 55	53
Europe:			
Austria	[r] 849	917	1,060
Belgium	[r] 3,284	3,559	[e] 3,800
Bulgaria [e]	1,047	1,047	1,047
Czechoslovakia [2]	2,485	2,668	2,903
Denmark	197	219	239
Finland	254	259	257
France	4,901	5,330	[e] 5,500
Germany, East	3,097	3,235	[e] 3,300
Germany, West	[r] 11,634	12,030	12,386
Hungary	[r] 672	702	737
Ireland	[r] 59	[r e] 72	84
Italy	4,630	[e] 4,400	[e] 4,400
Malta	[e] 61	65	[e] 66
Norway	110	[r e] 110	[e] 110
Poland [2]	[r] 6,735	7,210	8,483
Portugal	226	320	279
Romania	2,481	2,684	[e] 2,800
Spain	393	[r e] 440	[e] 440
Sweden [3]	[r] 936	916	[e] 915
Switzerland	[r] 156	165	152
U.S.S.R. [e]	[r] 23,000	[r] 24,000	24,000
Yugoslavia	1,755	1,284	1,125
Africa:			
Algeria	[r] 44	[r e] 44	[e] 44
Egypt, Arab Republic of	42	55	[e] 55
Ethiopia [4]	[r] 16	52	[e] 53
Mauritius	[e] 7	7	[e] 7
Mozambique	10	8	11
South Africa, Republic of (sales)	1,205	1,317	1,459
Tanzania	6	2	7
Tunisia	183	179	206
Uganda [e]	20	20	20
Zaire [e]	165	165	165
Zambia [e]	115	115	120
Asia:			
Cyprus	118	132	88
India	590	373	[e] 375
Iran [e]	1,100	1,100	1,100
Israel	198	198	[e] 200
Japan	10,934	11,166	13,024
Jordan	2	2	3
Kuwait [e]	1	1	1
Lebanon	138	[e] 132	168
Mongolia [e]	[r] 45	[r] 45	45
Philippines	[r] 245	312	166
Saudi Arabia	[e] 24	14	[e] 17
Taiwan	188	195	150
Oceania:			
Australia [e 5]	[r] 520	[r] 520	520
Fiji Islands	--	4	3
Total	[r] 109,789	113,566	118,820

[e] Estimate. [p] Preliminary. [r] Revised.

[1] Lime is produced in many other countries besides those listed. Mexico, Venezuela, and the United Kingdom are among the more important countries for which official data are unavailable.

[2] Excludes output by small producers.

[3] Includes burnt dolomite which was excluded in previous editions.

[4] Data for 1971 may be incomplete. Figures for 1972 and 1973 include production in Eritrea.

[5] Year ending June 30 of that stated.

TECHNOLOGY

The National Lime Association developed a new scrubber for removing sulfur from stack gases. Blaw-Knox Co. has been licensed to produce the scrubber.

The U.S. Army Corps of Engineers successfully injected lime slurry under pressure to a depth of 6 feet over a large area. The building erected at the site has shown no signs of settling, while adjacent buildings on unstabilized ground have settled drastically.

The Bureau of Reclamation completed a canal-lining project using lime. The canal bank was stabilized to a depth of 4 feet with 4% quicklime. After 10 months under 18 feet of water, the stabilized soil is hard and strong. Adjacent unstabilized sections have failed.

The Environmental Protection Agency was developing standards for air pollution in the lime industry.

Magnesium

By E. Chin [1]

Production and shipments of magnesium metal by The Dow Chemical Co. were 122,431 short tons and 137,277 short tons, respectively, in 1973. NL Industries, Inc. produced some metal at Rowley, Utah. The magnesium metal plant of American Magnesium Co. at Snyder, Tex., was not in operation throughout the year.

Legislation and Government Programs.—The General Services Administration (GSA) continued to dispose of all the magnesium remaining in the national stockpile. In 1972, GSA sold 7,737 short tons of metal from the Government stockpile, compared with 710 tons in 1971. A total of 66,638 short tons was sold during 1973. At yearend, the uncommitted excess in the stockpile was 23,205 short tons of magnesium metal.

[1] Physical scientist, Division of Nonferrous Metals—Mineral Supply.

Table 1.—Salient magnesium statistics

(Short tons)

	1969	1970	1971	1972	1973
United States:					
Production:					
Primary magnesium	99,887	112,006	123,485	120,823	122,431
Secondary magnesium	13,470	12,042	14,703	r 15,628	17,636
Shipments: Primary	117,695	118,693	120,217	111,185	137,277
Exports	27,372	35,732	24,311	17,556	39,585
Imports for consumption	4,316	3,295	3,671	4,479	3,283
Consumption	95,132	93,495	r 92,166	r 103,691	115,558
Price per pound cents	35.25	35.25	36.25	37.25	38.25
World: Primary production	221,469	242,253	255,753	255,960	261,110

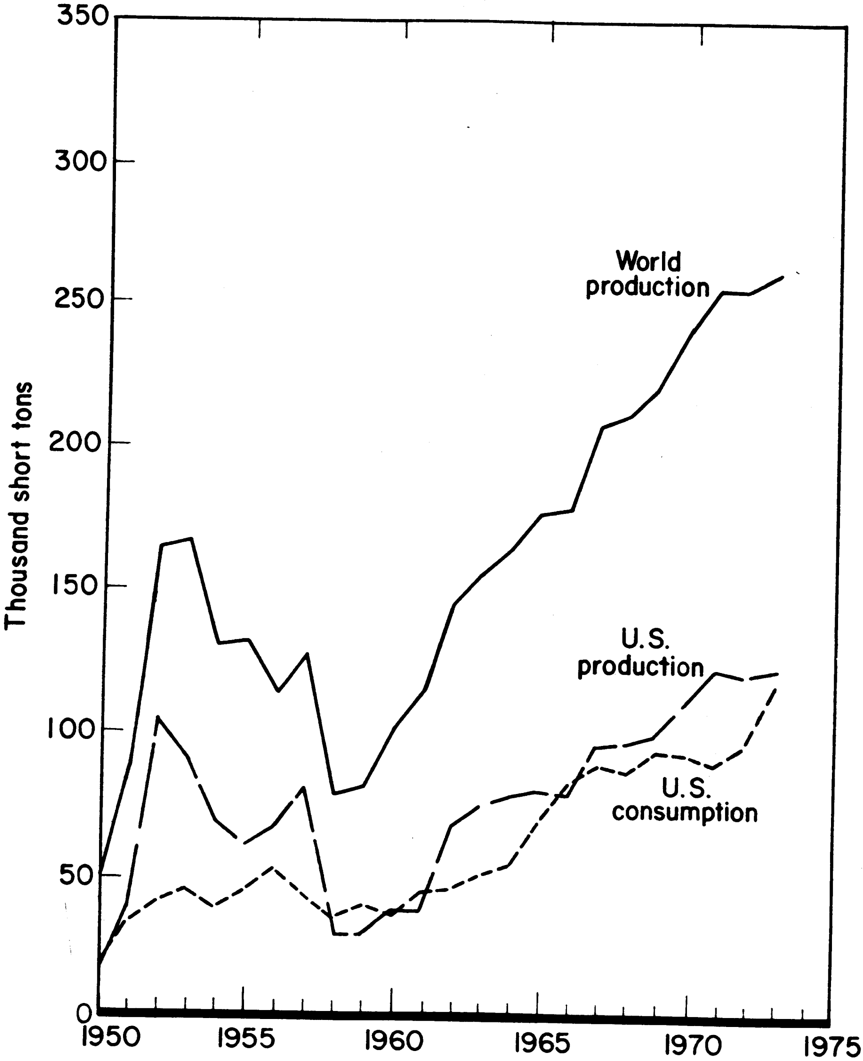

Figure 1.—U.S. and world production and U.S. consumption of primary magnesium.

DOMESTIC PRODUCTION

During the year, The Dow Chemical Co. completed an expansion program for producing metal at its plant in Freeport, Tex. Process modifications and improvements added 10 million pounds of annual capacity to its existing magnesium metal production capacity of 240 million pounds of metal. NL Industries, Inc., produced some metal in 1973 at Rowley, Utah, and was expected to produce magnesium at full rated capacity by late 1974. American Magnesium Co. was closed down throughout 1973, but was expected to resume production in mid-1974.

Northwest Alloys, Inc., a subsidiary of the Aluminum Co. of America (Alcoa), began constructing a new magnesium facility at Addy, Wash. Northwest Alloys will use the Magnetherm process for producing magnesium metal. Startup of this plant, with an intial capacity of 24,000 tons per year of magnesium and an ultimate capacity of 40,000 tons per year, was scheduled for late 1975.

Table 2.—Magnesium recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

	1969	1970	1971	1972 r	1973 p
Kind of scrap:					
New scrap:					
Magnesium-base	4,767	4,564	6,722	6,993	7,417
Aluminum-base	5,712	4,698	4,838	5,646	6,118
Total	10,479	9,262	11,560	12,639	13,535
Old scrap:					
Magnesium-base	1,700	1,518	1,719	1,445	2,529
Aluminum-base	1,291	1,262	1,424	1,544	1,572
Total	2,991	2,780	3,143	2,989	4,101
Grand total	13,470	12,042	14,703	15,628	17,636
Form of recovery:					
Magnesium alloy ingot [1]	3,231	2,006	3,905	3,612	2,606
Magnesium alloy castings (gross weight)	11	13	14	9	12
Magnesium alloy shapes	149	189	500	275	169
Aluminum alloys	8,378	7,088	7,423	8,790	9,206
Zinc and other alloys	13	24	17	14	31
Chemical and other dissipative uses	65	80	478	794	567
Cathode protection	1,623	2,642	2,366	2,134	5,045
Total	13,470	12,042	14,703	15,628	17,636

p Preliminary. r Revised.
[1] Figures include secondary magnesium content of both secondary and primary magnesium alloy ingot.

CONSUMPTION AND USES

Consumption of magnesium in the United States increased over that in 1972 to 115,558 short tons. Magnesium was consumed in two broad categories: Structural products such as castings and wrought products, and distributive or sacrificial applications where advantage is taken of the chemical properties of the metal. Useful structural properties of magnesium include low specific weight, good machinability, hot formability, and high strength. The principal structural applications, which account for about 23% of the total use, are in aircraft, automotive, and other types of transportation equipment, in materials handling, and in power tools, such as powersaws and lawnmowers. The remainder of the consumption is for sacrificial uses, primarily in alloying with other metals, especially aluminum, cathodic protection, production of nodular iron and the desulfurization of steel, and as a reducing agent in the production of titanium, beryllium, and other metals.

Table 3.—Consumption of primary magnesium in the United States, by use

(Short tons)

	1969	1970	1971 r	1972 r	1973 p
For structural products:					
Castings:					
Die	7,484	9,002	7,469	9,326	10,417
Permanent mold	404	260	142	736	885
Sand	2,562	1,735	765	700	1,420
Wrought products:					
Extrusions	13,110	12,250	5,587	7,749	8,254
Sheet and plate	(1)	(1)	2,918	3,817	4,167
Other (includes forgings)	(1)	(1)	2,212	1,381	1,427
Total	23,560	23,247	19,093	23,709	26,570
For distributive or sacrificial purposes:					
Alloys:					
Aluminum	37,375	36,543	37,450	43,458	50,860
Copper	(2)	(2)	163	38	505
Zinc	54	35	24	28	31
Other	(2)	(2)	37	109	13
Cathodic protection (anodes)	6,087	5,778	7,296	6,543	8,060
Chemical	(2)	8,385	8,960	9,732	11,589
Nodular iron	2,374	4,720	6,590	7,603	8,724
Powder	(2)	5,646	(2)	(2)	(2)
Scavenger and deoxidizer	(2)	(2)	68	327	50
Reducing agent for titanium, zirconium, hafnium, uranium, and beryllium	7,363	6,300	9,053	6,089	6,889
Other	18,319	2,841	3,432	6,055	2,267
Total	71,572	70,248	73,073	79,982	88,988
Grand total	95,132	93,495	92,166	103,691	115,558

p Preliminary. r Revised.
[1] Included with "Extrusions."
[2] Included with "Other."

PRICES

During 1973, the quoted base price for primary magnesium pig and ingot in 10,000-pound lots, 99.8% magnesium f.o.b. plant, was 38.25 and 39.00 cents per pounds, respectively, compared with corresponding prices of 37.25 and 38.00 cents per pound, respectively, during 1972.

Depending upon the state of preservation of the metal available from the national stockpile, GSA accepted bids for primary magnesium ranging from 31.75 to 39.30 cents per pound, f.o.b. storage locations. The average price of metal sold by GSA during the year, excluding the negotiated sales of magnesium, was 34.167 cents per pound.

STOCKS

Producer and consumer stocks of primary magnesium totaled 17,188 short tons as of December 31, 1973. Yearend stocks of primary magnesium alloy ingot were 1,706 tons. Stocks a year earlier were 22,011 short tons of primary metal and 986 short tons of alloy ingot.

Table 4.—Stocks and consumption of new and old magnesium scrap in the United States in 1973

(Short tons)

Item	Stocks Jan. 1 r	Receipts	Consumption			Stocks Dec. 31
			New scrap	Old scrap	Total	
Cast scrap	216	1,765	645	1,199	1,844	137
Solid wrought scrap [1]	1,132	4,046	4,577	--	4,577	601
Total	1,348	5,811	5,222	1,199	6,421	738

r Revised.
[1] Includes borings, turnings, drosses, etc.

FOREIGN TRADE

U.S. exports of magnesium increased from 17,556 short tons, valued at $11.7 million in 1972, to 39,585 tons, valued at $28.2 million in 1973. Shipments to West Germany, Brazil, the Netherlands, Canada, and Japan accounted for 19%, 17%, 15%, 14%, and 10%, respectively, of the total U.S. exports of magnesium. The remaining 10,399 tons were exported to approximately 20 countries.

Total magnesium imports for consumption decreased 27% from that of 1972. Canada, by far the largest of U.S. sources, contributed 27% of the metal imported. Receipts from the Netherlands and West Germany constituted 18% and 16%, respectively, of the magnesium imports. The remainder of U.S. imports, 1,280 tons, was contributed by 19 other nations.

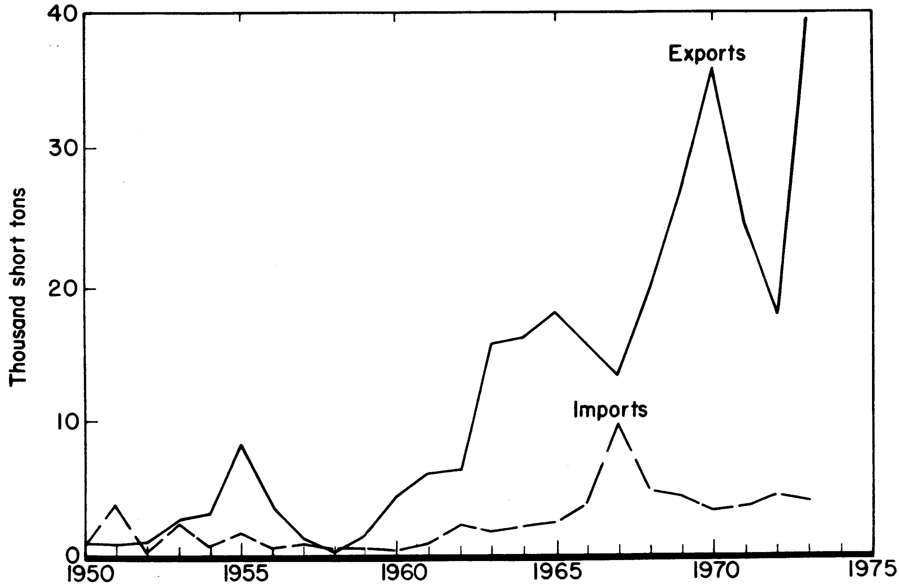

Figure 2.—U.S. imports and exports of magnesium.

Table 5.—U.S. exports of magnesium, by class and country

Destination	1972						1973					
	Waste and scrap		Primary metals, alloys		Semifabricated forms, n.e.c., including powder		Waste and scrap		Primary metals, alloys		Semifabricated forms, n.e.c., including powder	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Angola	--	--	2	$2	--	--	--	--	4	$5	--	--
Argentina	--	--	313	232	--	--	--	--	334	315	6	$47
Australia	--	--	312	168	45	$74	--	--	356	245	242	193
Austria	--	--	22	12	5	10	--	--	22	19	5	9
Belgium-Luxembourg	33	$11	135	78	1	6	12	$4	167	104	1	3
Brazil	--	--	5,439	3,360	3	10	--	--	6,548	4,365	--	--
Canada	27	80	3,253	1,907	289	397	10	44	5,189	3,374	243	454
Colombia	--	--	8	7	2	4	--	--	14	18	--	--
Egypt	--	--	34	24	--	--	--	--	1	(1)	--	--
France	--	--	432	247	17	48	--	--	335	222	4	14
Germany, West	--	--	801	506	58	154	--	--	7,185	4,727	167	383
Ghana	--	--	225	148	1	1	--	--	804	521	--	--
India	--	--	283	169	--	--	--	--	139	92	2	2
Indonesia	--	--	7	8	--	--	--	--	50	51	--	--
Israel	--	--	21	15	40	57	--	--	18	19	125	166
Italy	--	--	425	258	16	37	--	--	1,053	734	9	30
Japan	21	7	1,000	591	254	480	7	2	3,509	2,655	340	739
Mexico	11	15	938	609	5	10	12	17	3,271	2,174	9	17
Netherlands	--	--	385	228	21	36	--	--	5,966	3,846	22	52
Norway	--	--	95	56	--	--	--	--	523	341	(1)	1
South Africa, Republic of	--	--	190	113	1	1	--	--	594	480	3	4
Spain	--	--	386	219	2	3	--	--	686	413	4	10
Switzerland	--	--	721	444	6	10	--	--	29	17	15	36
Taiwan	--	--	129	70	(1)	1	--	--	155	121	(1)	1
United Kingdom	--	--	711	410	16	36	--	--	686	514	12	38
Venezuela	2	3	189	126	13	15	--	--	407	336	--	--
Other	(1)	(1)	186	125	25	64	3	14	278	226	9	28
Total	94	116	16,642	10,132	820	1,454	44	81	38,323	25,934	1,218	2,227

[1] Less than ½ unit.

Table 6.—U.S. exports and imports for consumption of magnesium

Year	EXPORTS					
	Waste and scrap		Metals and alloys in crude form		Semifabricated forms, n.e.c.	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1971	41	$107	23,298	$13,848	972	$1,737
1972	94	116	16,642	10,132	820	1,454
1973	44	81	38,323	25,934	1,218	2,227

Year	IMPORTS							
	Waste and scrap		Metal		Alloys (magnesium content)		Powder, sheets, tubing, ribbons, wire, and other forms (magnesium content)	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1971	2,142	$713	1,300	$920	99	$286	130	$397
1972	3,042	1,040	1,256	950	168	464	13	103
1973	2,296	952	578	452	389	1,104	20	129

WORLD REVIEW

World production of magnesium metal in 1973 was 261,110 short tons, an increase of 51,500 tons over world production in 1972. The United States produced 47% of the world magnesium output, followed by the U.S.S.R. 24%, and Norway 16%. The remainder of the world production was by Canada, the People's Republic of China, France, Italy, and Japan.

World producers of magnesium in 1973 with annual capacities, processes, and plant locations were as follows:

Country	Company	Capacity (short tons)	Process	Plant location
Canada	Chromasco Corporation Limited	12,000	Silicothermic	Haley, Ontario.
China, People's Republic of	NA	5,000	do	Ying-kou, Liaoning.
France	Société Générale du Magnesium Péchiney Ugine Kuhlmann S.A. (70%) Société des Produits Azotes (SPA) (30%).	9,000	do	Marignac.
Italy	Societá Italiana per il Magnesio e Leghe di Magnesio.	7,700	do	Bolzano.
Japan	Furukawa Magnesium Co	7,700	do	Koyama.
	UBE Industries, Ltd	6,600	do	Yamaguchi.
Norway	Heroya Electrokemiske Fabbrikker A/S subsidiary of Norsk Hydro-Elektrisk A/S.	47,000	I. G. Farbenindustrie	Heroya.
U.S.S.R.	NA	50,000	Electrolytic	NA.
United States	American Magnesium Co	30,000	do	Snyder, Tex.
	The Dow Chemical Co	125,000	Dow cells	Freeport, Tex.
	NL Industries, Inc	45,000	Electrolytic	Rowley, Utah.

NA Not available.

Japan.—Consumption of magnesium in Japan was estimated to be about 17,500 short tons in 1973 compared with 15,400 tons in 1972. Production was estimated to be 12,239 tons in 1973, compared with 12,004 tons in 1972. Imports of magnesium metal into Japan were expected to remain around 3,300 tons in 1973.

Norway.—Norsk Hydro-Elektrisk A/S (Norsk Hydro) announced that it will construct a magnesium production facility at Mongstad. The electrolytic plant will have an annual capacity of 55,100 short tons of metal per year and will be in operation about 1980. Additionally, Norsk Hydro developed a new magnesium chlo-

Table 7.—Magnesium: World production by country
(Short tons)

Country	1971	1972	1973 p
Canada	7,234	5,924	5,830
China, People's Republic of e	1,100	1,100	1,100
France	7,954	7,550	e 7,700
Italy	8,496	8,335	e 7,900
Japan	10,685	12,004	12,349
Norway	39,799	40,224	e 40,800
U.S.S.R.e	57,000	60,000	63,000
United States	123,485	[1] 120,823	[1] 122,431
Total	255,753	255,960	261,110

e Estimate. p Preliminary.
[1] Output of The Dow Chemical Co. only.

ride production process which will be tried in a plant at Heroya, scheduled to be built for the production of anhydrous magnesium chloride, and which would supply sufficient cell feed for the production of 16,500 short tons of metal.

United Kingdom.—The Minor Metals Traders' Association was formed in London in August 1973. Metals included in the association's groupings are magnesium, antimony, bismuth, cadmium, mercury, nickel, and selenium. The association, composed of 21 founding members, hopes to promote the interests of minor metal traders and give dealers in minor metals an entity separate from the London Metal Exchange.

U.S.S.R.—The All-Union Institute of Aluminum, Magnesium, and Electrolysis Industries announced the construction of a new electrolytic pilot plant for the production of magnesium metal and chlorine from magnesium chloride without the use of diaphragms. The new pilot plant, which produces about 2,200 pounds of magnesium and 6,000 pounds of chlorine per day, reportedly uses less floor space and lower power consumption.

TECHNOLOGY

Joseph Lucas Industries, Ltd., developed a system of dual sheet electrodes for multicell batteries.[2] A valuable characteristic of thin-film batteries is that thin sheets or strips can be stacked in electrical series so that high voltages can be produced from units with very small overall dimensions. A sheet of silver chloride is treated photographically to convert the silver chloride on one surface to metallic silver. When the silver chloride side of the sheet is juxtaposed with the face of a sheet of magnesium, the latter becomes an anode and a single cell is formed. The thin pairs of sheets can then be stacked to obtain whatever voltage is desired.

The 29th Annual Meeting of the International Magnesium Association was held at Cherry Hill, N.J., May 6–8, 1973. Papers on the uses of magnesium in steel desulfurization, in alloying, in potential uses by the automotive industry, and on the fluxless melting of magnesium and electrochemical applications for magnesium were presented.

Heretofore, magnesium has not been competitive with aluminum and zinc diecastings which are produced by the cold-chamber process. However, a hot chamber process has been developed for use with magnesium.[3] Equipment was designed for working temperatures of about 650° C and provisions were made to prevent the magnesium from oxidizing by blanketing the hot metal with a protective gas containing SO_2. The hot-chamber process offers a number of significant advantages. Production rates are high; the process lends itself to automation; air inclusions are less of a problem; and the temperature of injected molten metal is not only higher but more uniform in the hot-chamber process than in the cold-chamber process.

Magnesium has been traditionally used in the treatment of cast iron to produce spheroidal graphite iron, in which desulfurization by magnesium is an essential

[2] The Mining Record. Silver Makes Possible To Manufacture Thin Batteries. V. 84, No. 41, Oct. 10, 1973, p. 3.
[3] Iron Age. Hot Chamber Process Stirs Magnesium's Hopes. V. 212, No. 8, Aug. 23, 1973, pp. 49–50.

chemical reaction.[4] However, magnesium has the potential to be a major ingredient in the desulfurization of steel by the Mag-Coke process.[5] Based on metallurgical coke infiltrated with 45% by weight of magnesium, Mag-Coke is introduced into torpedo cars which are used to transfer hot molten iron from the blast furnace to the basic oxygen furnace. By this approach, the sulfur content of steel can be reduced to 0.01% by weight and thus improve the fracture toughness and formability of the end product.

Patents on the purification of magnesium chloride solutions to be used in the electrowinning of magnesium metal and on the purification of magnesium metal obtained from electrolytic cells were issued.[6]

[4] Fisher, P. A. Desulphurising Iron With Magnesium. Metal Bull. Monthly, No. 5793, Apr. 17, 1973, pp. 15–16.

[5] Iron Age. Mag-Coke Catches on as a Way to Produce Low-Sulfur Steels. V. 211, No. 20, May 17, 1973, p. 27.

[6] Boyum, O., F. E. Folkestad, and A. Torvund (assigned to Norsk Hydro A.S.). Electrowinning. U. S. Pat. 3,729,550, Apr. 24, 1973.

Bradshaw, W. L. (assigned to The Dow Chemical Co.). Electrowinning. U.S. Pat. 3,734,718, May 22, 1973.

Magnesium Compounds

By E. Chin [1]

World production of magnesite in 1973, excluding output in the United States was about 9,900,000 short tons, slightly higher than that in 1972. Magnesite production in Austria, Greece, North Korea, People's Republic of China, and the U.S.S.R. accounted for 74% of the world total.

The increasing worldwide trend toward greater production of magnesium compounds from sea water, well and lake brines, and dry lake deposits continued to exert competitive pressure on producers of magnesite. During 1973, two domestic companies, one using sea water as a raw material source and the other using well brines, announced the expansion of production capacity for magnesium compounds. A Japanese firm announced plans to produce magnesium hydroxide from a salt lake in Mexico.

Refractory magnesia, and caustic-calcined and specified magnesias, sold or used by domestic producers in 1973 were 17% above that in 1972. The value of domestic shipments of magnesias rose 27% to nearly $97,000,000 in 1973.

U.S. imports for consumption of processed magnesite in 1973 were about 158,000 short tons, with Greece accounting for 44% of the total. Exports of magnesite and magnesia were about 60,000 tons in 1973, and as in the 1970–72 period they were primarily to Canada.

[1] Physical scientist, Division of Nonferrous Metals—Mineral Supply.

Table 1.—Salient magnesium compounds statistics

(Thousand short tons and thousand dollars)

	1969	1970	1971	1972	1973
United States:					
Caustic-calcined and specified magnesias: [1]					
Shipments:					
Quantity	125	122	127	128	158
Value	19,876	19,301	18,621	15,856	26,929
Exports: [2]					
Value	2,687	3,200	2,840	3,377	4,196
Imports for consumption: [2]					
Value	983	702	736	675	734
Refractory magnesia:					
Sold and used by producers:					
Quantity	737	802	627	696	807
Value	51,843	60,333	50,359	60,331	69,943
Exports:					
Value	4,973	9,133	5,897	5,903	6,104
Imports:					
Value	5,913	7,357	9,219	9,300	13,435
Dead-burned dolomite:					
Sold and used by producers:					
Quantity	1,866	1,373	1,020	1,125	1,191
Value	35,580	25,740	19,128	21,097	22,335
World: Crude magnesite production:					
Quantity	10,627	9,763	r 10,061	9,842	9,864

r Revised.
[1] Excludes caustic-calcined magnesia used in production of refractory magnesia.
[2] Caustic-calcined magnesia only.

DOMESTIC PRODUCTION

Magnesium hydroxide was produced from sea water and well brines, by Barcroft Co., Basic Magnesia, Inc., Corhart Refractories Co. Inc., The Dow Chemical Co., Harbison-Walker Refractories Co., Kaiser Aluminum & Chemical Corp., Martin Marietta Chemicals, Merck & Co., Inc., and Michigan Chemical Corp. Most of the magnesium hydroxide produced was used in the production of magnesia for basic refractories. Producers of refractory magnesia were Basic Inc., Basic Magnesia, Inc., Corhart Refractories Co., A. P. Green Refractories Co., Harbison-Walker Refractories Co., Kaiser Aluminum & Chemical Corp., and Martin Marietta Chemicals Corp. Total production of refractory magnesia in 1973 was 702,278 tons.

Caustic-calcined magnesia was produced by Basic Inc., Basic Magnesia, Inc., The Dow Chemical Co., Kaiser Aluminum & Chemical Corp., Martin Marietta Chemicals Corp., and Michigan Chemical Corp. Merck & Co., Inc., Morton Chemical Co., and Michigan Chemical Corp., produced 12,532 tons of specified magnesia. The Dow Chemical Co., Giles Chemical Corp., and Philadelphia Quartz Co., produced 64,566 tons of magnesium sulfate (hydrous). During the year, 10,657 tons of magnesium carbonate were produced by Merck & Co., Inc. Morton Chemical Co., and Michigan Chemical Corp.

Magnesium chloride was produced by The Dow Chemical Co., FMC Corp., Great Salt Lake Minerals & Chemicals Corp., (GSL), and Kaiser Aluminum & Chemical Corp. Most of the magnesium chloride production was used for magnesium metal cell feed.

Early in 1973, Gulf Resources and Chemical Corp. acquired all of theh stock of GSL Corp. from its former German partner, Kali & Salz A.G. GSL produces magnesium chloride brines, potash, sodium sulfate, and industrial salt. In July, GSL began construction of a 3,500-acre addition to its existing solar evaporation ponds, costing $1.2 million. The completion of the expansion program was scheduled for 1974.

The Dow Chemical Co. announced an expansion of magnesium oxide production capacity at its facilities in Freeport, Tex. Completion, scheduled for mid-1974, will boost its magnesium oxide capacity by approximately 35,000 tons per year.

The U.S. Atomic Energy Commission approved the Consumers Power petition for a proposed nuclear powerplant at Midland, Mich. The 1.3 million-kilowatt installation was designed to deliver up to 4 million pounds per hour of steam for industrial use by The Dow Chemical Co. at its Midland, Mich., installation.

Table 2.—Dead-burned dolomite sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Sales of domestic product: Quantity	Sales of domestic product: Value
1969	1,866	33,580
1970	1,373	25,740
1971	1,020	19,128
1972	1,125	21,097
1973 p	1,191	22,335

p Preliminary.

Martin Marietta began an expansion of its Manistee, Mich., chemical plant, which will result in a 50,000-ton-per-year increase in the production capacity for periclase and a 30,000-ton-per-year increase in the production of magnesium chemicals. The Manistee plant is a unit of the Refractories Division of Martin Marietta. Plans for the Manistee expansion provide for a complete, new, high-purity periclase plant, which is a duplication of the periclase manufacturing plant that Martin Marietta placed on-line there in 1969. The plans also include the installation of a multiple-hearth calcining furnace, briquetting presses, and a high-temperature shaft kiln. In addition, new brine wells, hydrate facilities, and extensive water and air emission controls are included. Completion of the Manistee plant expansion program was scheduled for early in 1975.

Kaiser Aluminum & Chemical Corp. completed the installation of three wet scrubbers on its kiln air discharge system to prevent dust emission at its sea water magnesia plant at Moss Landing, Calif. The first wet scrubber was placed in operation in March 1972, the second in December 1972, and the third in June 1973. The scrubbers replaced the precipitator used formerly and reportedly will improve plant efficiency and air pollution control effectiveness.

Domestic producers of magnesium compounds by raw material source, location, and capacity are as follows:

Raw material source and producing company	Location	Capacity (short tons MgO equivalent)
Magnesite:		
Basic, Inc	Gabbs, Nev	150,000
Lake brines:		
Great Salt Lake Minerals & Chemicals Corp	Ogden, Utah	100,000
NL Industries, Inc	Rowley, Utah	75,000
Kaiser Aluminum & Chemical Corp	Wendover, Utah	50,000
Well brines:		
American Magnesium Co	Snyder, Tex	50,000
The Dow Chemical Co	Ludington, Mich	250,000
Martin Marietta Chemicals Corp	Manistee, Mich	180,000
Michigan Chemical Corp	St. Louis, Mich	25,000
Morton Chemical Co	Manistee, Mich	5,000
Seawater:		
Basic Magnesia, Inc	Port St. Joe, Fla	100,000
Barcroft Co	Lewes, Del	5,000
Cohart Refractories Co., Inc	Pascagoula, Miss	40,000
The Dow Chemical Co	Freeport, Tex	285,000
FMC Corp	Chula Vista, Calif	5,000
Kaiser Aluminum & Chemical Corp	Moss Landing, Calif	150,000
Merck & Co., Inc	Cape May, N.J	100,000
Harbison-Walker Refractories Co	Cape May, N.J	100,000
Total		1,580,000

CONSUMPTION AND USES

In 1973 magnesia used in the production of basic refractories increased 16% over that in 1972. Consumption of caustic-calcined magnesia for uses other than the production of refractory magnesia also increased significantly.

Magnesia is used as a fuel additive in burning heavy fuel at steam generating plants to prevent corrosion and acid smut fallout. It is also used for stack gas scrubbing. As an additive to animal feed, magnesia prevents grass tetany in cattle and sheep, promotes increased egg laying, and increases the butterfat content of milk. In sugar cane processing mills, magnesia prevents scale formation in the evaporators. As an additive in rubber, magnesia is used to neutralize acidity, to keep the molds cleaner, and to improve the rubber cure rate. Other uses for magnesia are in chemicals, construction materials such as plaster and cement, cosmetics, electrical heating rods, fertilizers, medicinals and pharmaceuticals, and pulp and paper.

Other magnesium compounds are used in candy, wine, and water processing; in tannery applications; and in cosmetics and pharmaceuticals.

Table 3.—Magnesium compounds shipped and used in the United States

Year and product	Shipped and used: Quantity (short tons)	Shipped and used: Value (thousands)
1972		
Caustic-calcined[1] and specified (U.S.P. and technical) magnesias	128,260	$15,856
Refractory magnesia	696,102	60,331
Magnesium hydroxide (100% $Mg(OH)_2$)[1]	66,671	[r] 3,606
Magnesium sulfate (anhydrous and hydrous)	[e] 61,500	[e] 4,400
Precipitated magnesium carbonate[1]	5,074	1,476
1973		
Caustic-calcined[1] and specified (U.S.P. and technical) magnesias	157,668	$26,929
Refractory magnesia	806,548	69,904
Magnesium hydroxide (100% $Mg(OH)_2$)[1]	83,324	4,857
Magnesium sulfate (anhydrous and hydrous)	63,011	4,551
Precipitated magnesium carbonate[1]	5,036	1,746

[e] Estimate. [r] Revised.

[1] Excludes material produced as an intermediate step in the manufacture of other magnesium compounds.

Table 4.—Domestic shipments of caustic-calcined and specified magnesias, by use

(Short tons)

Use	1972	1973
Agriculture, nutrition, and pharmaceuticals:		
Animal feed and fertilizer	23,498	33,992
Medicinals and pharmaceuticals	(1)	(1)
Sugar, candy, and winemaking	4,532	4,939
Total	28,030	38,931
Construction materials:		
Insulation and wallboard	(2)	(2)
Oxychloride and oxysulfate cement	17,315	19,441
Total	17,315	19,441
Chemical processing, manufacturing, and metallurgical:		
Chemical	33,831	41,264
Electrical heating rods	2,364	2,852
Flux	W	--
Petroleum additive	W	W
Pulp and paper	15,312	13,760
Rayon	W	12,145
Rubber	7,411	11,893
Uranium processing	W	W
Water treatment	W	W
Total	72,712	84,409
Unspecified uses	10,203	14,887
Grand total	128,260	157,668

W Withheld to avoid disclosing individual company confidential data; included with "Total."
[1] Included with "Sugar, candy and winemaking."
[2] Included with "Oxychloride and oxysulfate cement."

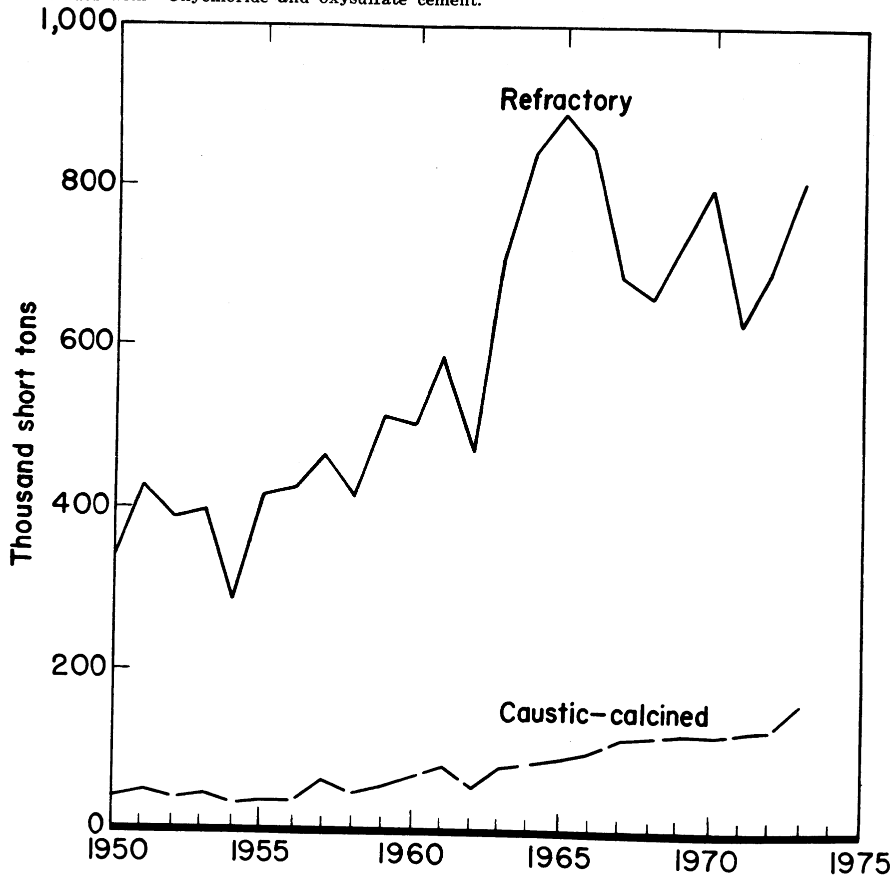

Figure 1.—Consumption and shipments of magnesia in the United States.

PRICES

Prices for magnesia, calcined, technical, heavy, 85% and 90% (bags, carlot, f.o.b. Luning, Nev.) were quoted during the year at $50 and $60 per short ton, respectively, according to the Chemical Marketing Reporter. Magnesia, technical, synthetic rubber–grade, neoprene-grade, light, was quoted at $0.25 per pound (bags, carlot, freight-equalized).

Prices throughout the year for magnesium carbonate, technical (bags, carlot, freight-equalized), remained the same as in 1972 at $0.16 per pound and for truckload quantities at $0.18 to $0.185 per pound with no change from the 1972 rate. During the year, the price for magnesium hydroxide, NF, powder (drums, carlot, and truckload, works) was $0.30 per pound. Magnesium chloride, hydrous, 99%, flakes, bags, carlot, works, was quoted at $80 per ton. The price for magnesium lauryl sulfate, tanks freight-allowed, remained the same as in 1972, at $0.175 per pound.

FOREIGN TRADE

Exports of dead-burned magnesite and magnesia in 1973 totaled 50,760 short tons compared with 54,159 tons in 1972. Exports to the principal destination, Canada, were 42,540 tons, 18% lower than in 1972. However, shipments to Mexico, the Netherlands, and West Germany in 1973 were substantially higher than in the previous year.

Exports of magnesite, including crude, caustic-calcined, lump or ground, increased over exports in 1972 and totaled 9,304 tons. Deliveries to Australia, Canada, Italy, Mexico, and West Germany accounted for over 61% of the exports in this class.

Lump or ground caustic-calcined magnesia imports for consumption increased slightly in 1973 to 10,967 tons and were principally from India and Turkey.

Imports of dead-burned and grain magnesia and periclase containing a maximum of 4% lime increased 17% to 149,051 short tons in 1973. Imports for the same class of material but containing over 4% lime increased from 5,958 tons in 1972 to 8,956 tons in 1973. Total imports of crude and processed magnesite increased 17% over those in 1972 to 168,974 short tons.

Imports of specified magnesium compounds and compounds, not specifically provided for, were valued at $1,880,000 in 1973 compared with $1,111,000 in 1972.

Table 5.—U.S. exports of magnesite and magnesia, by country

(Short tons and thousand dollars)

Destination	Magnesite and magnesia, dead-burned				Magnesite, n.e.c., including crude caustic-calcined, lump or ground			
	1972		1973		1972		1973	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	774	115	7	1	113	51	119	60
Australia	20	9	21	14	442	237	976	470
Belgium-Luxembourg	--	--	--	--	87	36	73	35
Brazil	11	6	31	14	122	57	168	79
Canada	51,694	5,064	42,540	4,477	1,105	486	1,771	762
Chile	329	22	864	86	75	23	6	3
Colombia	--	--	--	--	19	10	42	23
Costa Rica	--	--	--	--	1	(1)	2	1
Denmark	--	--	--	--	28	17	13	6
El Salvador	5	1	5	2	--	--	--	--
Finland	6	4	1	1	181	100	335	197
France	50	5	98	8	342	209	347	209
Germany, West	180	98	3,108	524	1,269	598	1,377	719
Honduras	--	--	40	6	25	4	--	--
Israel	--	--	8	4	29	15	33	17
Italy	18	15	--	--	701	332	946	206
Japan	55	39	185	29	26	14	48	20
Mexico	7	4	858	87	78	22	610	214
Netherlands	48	17	1,638	239	182	72	202	82
New Zealand	32	21	5	4	125	81	293	130
Peru	--	--	--	--	12	6	11	5
Philippines	27	7	45	15	5	3	38	21
South Africa, Republic of	104	75	129	93	200	94	154	85
Spain	1	(1)	--	--	151	63	186	77
Sweden	72	50	82	66	362	262	464	296
Switzerland	16	3	--	--	51	20	74	30
Taiwan	--	--	66	11	168	52	32	10
U.S.S.R	--	--	221	66	54	42	--	--
United Kingdom	566	321	469	299	634	297	514	290
Venezuela	50	7	267	41	154	20	280	40
Yugoslavia	--	--	--	--	80	53	68	45
Other	94	20	72	17	216	101	122	64
Total	54,159	5,903	50,760	6,104	7,037	3,377	9,304	4,196

[1] Less than ½ unit.

Table 6.—U.S. imports for consumption of crude and processed magnesite, by country

(Short tons and thousand dollars)

Country	1972 Quantity	1972 Value	1973 Quantity	1973 Value
Lump or ground caustic-calcined magnesia:				
Australia	231	27	172	15
Austria	520	19	121	7
Greece	917	82	--	--
India	6,711	378	7,885	435
Japan	--	--	221	17
Netherlands	222	20	302	36
Turkey	1,775	149	2,246	222
United Kingdom	--	--	20	2
Total	10,376	675	10,967	734
Dead-burned and grain magnesia and periclase:				
Not containing lime or not over 4% lime:				
Australia	964	96	1,105	136
Austria	8,323	526	4,568	354
Brazil	--	--	2,752	163
Canada	112	12	30	7
Germany, West	6	3	--	--
Greece	76,921	5,360	66,746	6,322
Ireland	24,827	2,004	33,226	2,744
Italy	3	(1)	6,837	820
Japan	5,434	364	26,805	2,325
Mexico	3	(1)	--	--
Poland	5,616	468	--	--
United Kingdom	5,556	466	6,982	564
Yugoslavia	11	1	--	--
Total	127,776	9,300	149,051	13,435
Containing over 4% lime:				
Austria	2,717	163	--	--
Canada	3,208	230	2,056	84
Greece	--	--	1,990	98
Yugoslavia	33	2	4,910	260
Total	5,958	395	8,956	442
Total dead-burned, grain magnesia and periclase	133,734	9,695	158,007	13,877

[1] Less than ½ unit.

Table 7.—U.S. imports for consumption of magnesium compounds

(Short tons and thousand dollars)

Year	Oxide or calcined magnesia		Magnesium carbonate (precipitated)		Magnesium chloride (anhydrous)		Magnesium chloride (other)		Magnesium sulfate (epsom salts and kieserite)		Magnesium salts and compounds, n.s.p.f. [1]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1971	628	222	138	60	26	2	435	15	45,597	654	2,889	304
1972	690	256	139	73	22	1	250	8	21,538	378	2,662	395
1973	673	292	138	88	121	45	301	16	52,489	962	3,307	477

[1] Includes magnesium silicofluoride or fluosilicate and calcined magnesia.

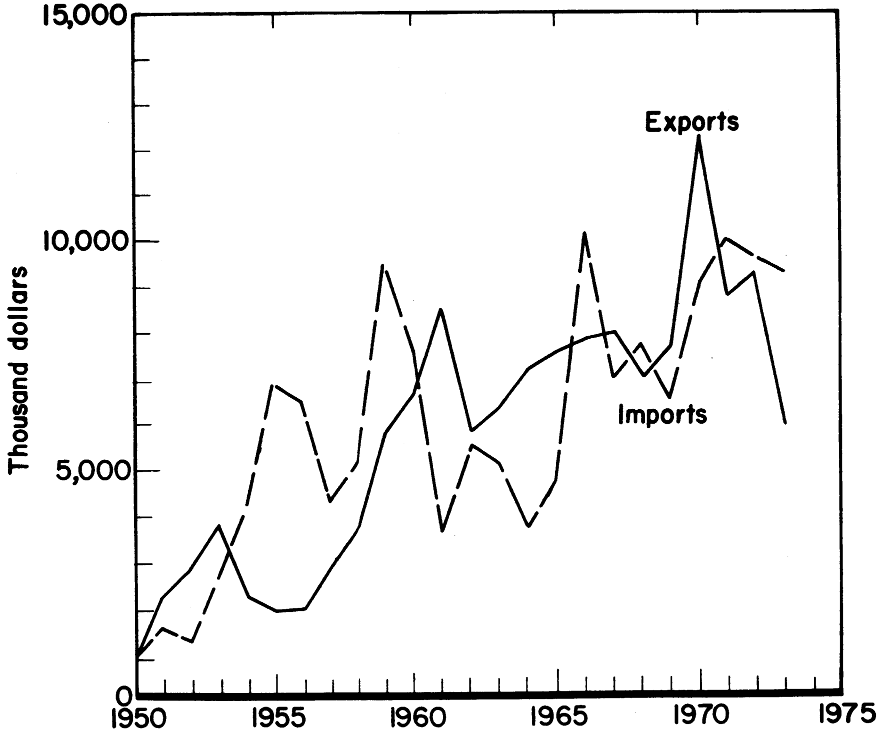

Figure 2.—Value of U.S. exports and imports of magnesia.

WORLD REVIEW

Brazil.—A new project to produce dead-burned magnesite for basic refractories was to be established in northeast Brazil. The facilities, which will be operated by Refractories do Nordeste S.A. of Fortaleza in Ceará State, were expected to cost over $13.6 million. The Export-Import Bank was to partly finance a $4.9 million loan to cover the design, construction, and equipment for the project.

Kalium Mineraçãos announced it will develop a magnesium, potassium, and rock salt deposit in Sergipe. Initial plans called for the installation of a potassium treatment plant with a capacity of 500,000 short tons per year; this phase was scheduled for completion by yearend 1973. Total cost of the project was estimated at $300 million and was reportedly to be raised by local financing.

Canada.—Canadian Johns-Manville Co., Ltd., terminated its agreement with Canadian Magnesite Mines, Ltd., to assist in the development of a mining operation at Timmins, Ontario. The original plans called for the production of magnesite and talc.

Lundigran Ltd., in conjunction with prospective U.S. partners, announced that it hoped to reopen the Aguaguntha magnesia plant in west Newfoundland. The plant, which was built in 1968, has been shutdown since August 1970.

Greece.—Société Financière de Grèce (Scalistiri) started operation of its first magnesite brick plant at Fourni (near Mantoudi), on the island of Euboea. Scalistiri, which produces over 70% of Greek magnesite exports, began mining magnesite in Euboea in 1959. Initially, raw magnesite was exported, but in 1967 rotary kilns were installed to produce dead-burned magnesite. In 1970, a dressing plant with a capacity of 100,000 short tons per year was installed

Table 8.—Magnesite: World production by country[1]

(Short tons)

Country	1971	1972	1973 p
North America: United States	W	W	W
South America:			
Brazil e	296,000	r 275,000	275,000
Mexico	14,350	22,992	e 23,000
Europe:			
Austria	1,715,700	1,575,657	1,558,972
Czechoslovakia	682,288	e 680,000	e 680,000
Greece	r 1,049,976	1,026,976	e 1,025,000
Poland e	55,000	55,000	55,000
Spain	284,947	297,624	e 300,000
U.S.S.R. e	1,600,000	1,650,000	1,710,000
Yugoslavia	543,126	464,815	423,287
Africa:			
Kenya	244	e 250	e 250
Rhodesia, Southern e	22,000	22,000	22,000
South Africa, Republic of	86,711	75,830	e 84,000
Sudan e	110	110	110
Tanzania	r 1,082	894	e 880
Asia:			
China, People's Republic of e	1,100,000	1,100,000	1,100,000
India	r 326,287	300,933	e 303,000
Iran 2	23,000	3,300	e 5,500
Korea, North e	1,900,000	1,900,000	1,900,000
Pakistan	239	324	e 330
Turkey	339,306	367,384	e 375,000
Oceania:			
Australia	r 19,937	22,044	e 22,000
New Zealand	1,154	1,058	e 1,100
Total	r 10,061,457	9,842,191	9,864,429

e Estimate. p Preliminary. r Revised. W Withheld to avoid disclosing individual company confidential data.

[1] Figures represent crude salable magnesite. In addition to the countries listed, Bulgaria, Canada, and Colombia produce magnesite, but output is not reported and available information is inadequate to make reliable estimates of output levels.

[2] Year beginning March 21 of that stated.

to maximize recovery of the magnesite from the mining operation. The new refractory brick plant has an annual capacity of 42,000 tons; 18,000 tons will be either white or tar-impregnated fire bricks and the remainder tar bonded brick. Additionally, Scalistiri was conducting research to increase the use of process fines from ore only amenable to fine grinding.

India.—The Uttar Pradesh State Industrial Corp. and Belpahar Refractories Ltd. of Jamshedpur have jointly subscribed to the construction of a magnesite operation at Kafligarh in the Almora district of Uttar Pradesh. The project, which will cost 23 million Rupees,[2] was designed to produce approximately 110 short tons of deadburned magnesite per day.

Mexico.—Mitsubishi Corp. agreed to pay $20 million to Seatankers, Inc., the owner of Exportadora de Sal S.A., for the salt field in Baja California, Mexico. Seatankers, Inc., is a subsidiary of the U.S. firm National Bulk Carriers, Inc. The Japanese trading firm planned to product and export magnesium hydroxide, bromine, and salt.

Nepal.—The Nepal Bureau of Mines announced the location of a large, high-grade magnesite deposit at Kharidhunga, a village in the Sindupalchock district, approximately 60 miles northeast of Kathmandu. The deposit was estimated to contain approximately 180 millon short tons of magnesite. Results of core drilling to determine the extent of mineralization and beneficiation tests of the ore were favorable and indicated that a mining operation and prodution facilities for basic refractory brick should be established.

Sea water magnesia production facilities throughout the world by country, location, company, and capacity are as follows:

[2] Because of fluctuating exchange rates, a meaningful conversion to U.S. dollars is impractical.

Country	Location	Company	Capacity (short tons MgO)
Canada	Aguathuna, Newfoundland	Lundrigan's Ltd	30,000
Ireland	Dungarvan, Waterford	Pfizer Chemical Corp	75,000
Israel	Arad	Dead Sea Works, Ltd	50,000
Italy	Syracuse, Sicily	Compagnia Generale de Magnesio S.p.A.	60,000
	Sant'Antioco, Sardinia	Sardamag S.p.A	120,000
Japan	Hotsu	Hokuriku Seien Kogyo K.K.	72,000
	Navetsu	Nihon Kasui Kako Co	55,000
	Minamata, Onohama, Toyama	Shin-Nihon Chemical Industries Co.	187,000
	Ube, Yamaguchi	Ube Chemical Industries	440,000
Mexico	Ciudad Madero, Tampico	Quimica del Mar SA	50,000
Norway	Heroya, Oslo Fjord	Norsk Hydro-Elektrisk Kvaelstof A/S.	80,000
China, People's Republic of	Liaoning, Manchuria		10,000
U.S.S.R	NA		100,000
United Kingdom	Hartlepool County, Durham	Steetley, Ltd	250,000
United States	(1)	(1)	695,000
Total			2,274,000

NA Not available.
[1] Sea water production facilities appear in tabulation shown in "Domestic Production" section of this chapter.

TECHNOLOGY

The first large-scale test of the patented process developed by Chemical Construction Corp. and Basic Chemicals of Cleveland (Chemico/Basic), which uses magnesium hydrate to recover sulfur dioxide from powerplant emissions, was in operation at the Mystic station of Boston Edison Co.[3] Results demonstrated that over 90% of the sulfur dioxide gases previously emitted from one of the 150-megawatt oil-fired boilers could be converted to marketable sulfuric acid. The stack gases were scrubbed in a large tower containing hydrated magnesium oxide. The sulfur gases reacted with the magnesium hydroxide to form magnesium sulfite, which was then dried. The sulfite was reduced to the oxide of magnesium and sulfur; the former was recycled for use in the scrubbing tower and the latter was converted into sulfuric acid.

The Mystic station test, which is being conducted in cooperation with the U.S. Environmental Protection Agency, will also include a series of experiments to determine the effectiveness of the Chemicó/Basic process under various operating conditions. Additionally, Chemico/Basic was installing a similar recovery system at a coal-fired powerplant operated by Potomac Edison Co. in Maryland.

Other methods for removing sulfur dioxide from emissions using magnesium oxide were described.[4] A summary of patents on refractories issued between November 14, 1972, and March 27, 1973, was published by The Refractories Institute production of basic refractory products containing magnesium oxide and magnesite.

Carboline Co. has developed a proprietary catalyst that controls the stability and setting speed of magnesium oxychloride plaster used for fireproofing structural steel.[5] The catalyst enables the plaster to be sprayed onto the surface about 1½ hours after the material has been mixed. Advantages of this plaster material include the lower cost compared with other types of structural steel fireproofing materials; its ability to generate water when exposed to high heat; the ease with which it can be removed after being exposed to fire so that fresh plaster can be applied; and its suitability for weathering in exterior applications.

The Chemicotechnological Institute in the Soviet Union developed a technique that results in a silver electroplate which is more resistant to tarnish.[6] By adding magnesium sulfate to an aqueous silver nitrate electrolyte, the resultant silver electroplate was found to be five times more resistant to tarnish than usual.

[3] Industrial Minerals. Chemico/Basic's Success in SO_2 Recovery. No. 70, July 1973, p. 27.
[4] Chemical Engineering. Sulfur Dioxide Recovery. V 80, No. 17, July 23, 1973, p. 111.
Chemical Week. A New Type of Gas Absorption Tower for Removing Sulfur Dioxide. V. 112, No. 14, Apr. 4, 1973, p. 47.
[5] Chemical Week. Plaster Cools It. V. 113, No. 3, July 18, 1973, p. 25.
Oil and Gas Journal. New Plaster Material Improves Fire Protection. V. 71, No. 4, Jan. 22, 1973, p. 78.
[6] Skillings Mining Review. Tarnish Resistant Silver. V. 62, No. 27, July 7, 1973, p. 32.

Manganese

By Gilbert L. DeHuff [1]

Although a small quantity of manganese nodules was shipped from stocks, there was no actual domestic production of manganese ore, concentrate, or nodules, containing 35% or more manganese, in 1973. With demand high, imports of ferromanganese exceeded the record high established in the previous year, while domestic production dropped and prices of ore, alloy, and metal increased. The General Services Administration (GSA) pressed its sales of surplus stockpile manganese ores, alloys, and metal; and private industry actively continued research that it hoped would lead to commercially mining the nodules of the deep-sea floors.

Legislation and Government Programs.—The Acting Director, Office of Emergency Preparedness, on April 12 revised downward all manganese stockpile objectives. The new objectives were established as follows, in short tons: Natural battery ore, 10,700; synthetic dioxide, none; type A chemical ore, 12,800; type B chemical ore, 12,800; metallurgical ore, 750,500; high-carbon ferromanganese, 200,000; medium-carbon ferromanganese, 10,500; low-carbon ferromanganese, zero; silicomanganese, 15,900; and electrolytic metal, 4,750.

Cumulative sales of stockpiled manganese items for the calendar year, as reported by GSA, were as follows (short tons): Synthetic dioxide, 1,681; type B chemical ore, 600; metallurgical ore, 2,406,617 of stockpile grade and 315,484 of nonstockpile grade; high-carbon ferromanganese, 342,148; and electrolytic metal 7,351.

In June, GSA increased its limit for deliveries of metallurgical ore to 500,000 tons for each of fiscal years 1973 and 1974. In December, the limit for fiscal year 1974 was increased to 750,000 tons. Manganese stockpile inventory changes in calendar year 1973 consisted of the following: Synthetic dioxide decreased 2,481 short tons to 14,538 tons; type A chemical ore decreased 328 tons to 146,586 tons; type B chemical ore decreased 167 tons to 100,671 tons; metallurgical ore, stockpile grade, decreased 423,502 tons to 7,249,034 tons; metallurgical ore, nonstockpile grade decreased 11,889 tons to 1,377,882 tons; high-carbon ferromanganese was down 64,536 tons to 1,111,525 tons; medium-carbon ferromanganese down 1 ton to 28,920 tons; and electrolytic metal decreased 3,358 tons to 18,153 tons.

[1] Supervisory physical scientist, Division of Ferrous Metals—Mineral Supply.

Table 1.—Salient manganese statistics in the United States

(Short tons)

	1969	1970	1971	1972	1973
Manganese ore (35% or more Mn):					
Production (shipments)	5,630	4,737	142	578	239
Imports general	1,959,661	1,735,055	1,914,264	1,620,252	1,509,793
Consumption	2,181,333	2,363,937	2,155,454	2,331,459	2,140,058
Manganiferous ore (5% to 35% Mn):					
Production (shipments)	430,637	368,302	198,334	147,161	203,055
Ferromanganese:					
Production	852,019	835,463	759,896	800,723	683,075
Exports	1,759	21,747	4,526	6,842	8,574
Imports for consumption	307,891	290,946	242,778	348,539	390,367
Consumption	1,071,042	1,000,611	899,011	967,968	1,116,602

DOMESTIC PRODUCTION

Except for a small quantity of metallurgical oxide nodules shipped from old stocks by The Anaconda Company, there was neither production nor shipment of manganese ore, concentrate, or nodules, containing 35% or more manganese, in the United States in 1973.

Ferruginous manganese ores or concentrates containing 10% to 35% manganese were produced and shipped from New Mexico, and shipments continued from the Cuyuna Range of Minnesota. Manganiferous iron ore containing 5% to 10% manganese was neither produced nor shipped in either 1973 or 1972. Manganiferous zinc residuum continued to be recovered from New Jersey zinc ores.

Table 2.—Manganese and manganiferous ore shipped [1] in the United States, by State

(Short tons)

Type and State	1972		1973	
	Gross weight	Manganese content	Gross weight	Manganese content
Manganese ore (35% or more Mn, natural): Montana	578	305	239	125
Total	578	305	239	125
Manganiferous ore:				
Ferruginous manganese ore (10% to 35% Mn, natural):				
Minnesota	119,324	15,081	170,971	21,526
New Mexico	27,837	3,646	32,084	4,171
Total	147,161	18,727	203,055	25,697
Manganiferous iron ore (5% to 10% Mn, natural)	--	--	--	--
Total manganiferous ore	147,161	18,727	203,055	25,697
Value manganese and manganiferous ore	$1,040,000	--	$1,531,390	--

[1] Shipments are used as the measure of manganese production for compiling U.S. mineral production value. They are taken at the point at which the material is considered to be in marketable form for the consumer. Besides direct shipping ore, they include, without duplication, concentrate and nodules made from domestic ores.

CONSUMPTION, USES, AND STOCKS

In the production of raw steel (ingots, continuous- or pressure-cast blooms, billets, slabs, etc., and including steel castings), consumption of manganese as ferroalloys, metal, and direct-charged ore was 12.9 pounds per short ton of raw steel produced. Of this total, 11.1 pounds was ferromanganese; 1.3 pounds, silicomanganese; 0.05 pound, spiegeleisen; 0.25 pound, manganese metal; and 0.2 pound, manganese ore. The comparable 1972 total, on the same basis, was 12.6 pounds with ferromanganese at 11.0, silicomanganese at 1.2, spiegeleisen at 0.05, metal at 0.25, and ore at 0.1. In addition to the aforementioned consumption of manganese in 1973, there was consumed per short ton of raw steel produced approximately 1.1 pounds of manganese contained in manganese ore used in making pig iron. In 1972, the quantity was approximately 1.2 pounds.

Domestic producers of manganese ferroalloys continued their capital expenditures for pollution controls, and continued to have problems of power supply. Union Carbide Corp. converted a ferrochromium furnace at its Marietta, Ohio, plant to the production of standard ferromanganese, reportedly making this the first furnace in the country of 35,000 kilovolt-ampere or larger size used for producing standard ferromanganese. The company stopped production of both ferromanganese and silicomanganese at the Ashtabula, Ohio, plant, apparently converting those furnaces to production of silicon ferroalloys.

Electrolytic Manganese Metal.—All of the manganese metal produced domestically was electrolytic, and it is certain that virtually all of that imported was electrolytic metal. Virtually all of the metal consumed was electrolytic metal, but it is possible that some low-carbon ferromanganese, and possibly some manganese-aluminum additives, may have been erroneously reported by consumers as manganese metal.

Table 3.—Consumption and industry stocks of manganese ore [1] in the United States

(Short tons)

	Consumption 1972	Consumption 1973	Stocks Dec. 31, 1973
By use:			
Manganese alloys and metal	1,925,715	1,684,127	1,019,120
Pig iron and steel	211,157	237,807	218,348
Dry cells, chemicals and miscellaneous	194,587	218,124	305,826
Total	2,331,459	2,140,058	1,543,294
By origin:			
Domestic	r 29,206	35,961	47,664
Foreign	r 2,302,253	2,104,097	1,495,630
Total	2,331,459	2,140,058	1,543,294

r Revised.
[1] Containing 35% or more manganese (natural).

Table 4.—Consumption, by end use, and industry stocks of manganese ferroalloys and metal in the United States, in 1973

(Short tons, gross weight)

End use	Ferromanganese High-carbon	Ferromanganese Medium and low-carbon	Silico-manganese	Spiegel-eisen	Manganese metal [1]
Steel:					
Carbon	764,684	120,958	94,630	11,118	8,133
Stainless and heat resisting	5,149	5,194	12,458	1	7,580
Full alloy	81,169	24,852	29,929	1,653	1,784
High-strength low-alloy	71,350	9,994	8,018	120	712
Electric	430	293	1,145	--	17
Tool	1,549	275	51	--	650
Cast irons	19,995	1,944	4,907	8,695	39
Superalloys	331	W	W	--	358
Alloys (excludes alloy steels and superalloys)	4,940	1,481	2,785	26	14,595
Miscellaneous and unspecified	934	1,080	5,096	--	1,375
Total	950,531	166,071	159,019	21,613	35,243
Stocks, December 31	222,875	33,557	42,992	3,732	4,795

W Withheld to avoid disclosing individual company confidential data; included in "Miscellaneous and unspecified."
[1] Virtually all electrolytic.

The metal used to make manganese-aluminum additives is included in table 4 under the "Alloys (excludes alloy steels and superalloys)" category. Production of electrolytic metal in 1973 was 26,175 short tons, compared with 23,200 tons in 1972, and was by the same three companies: Foote Mineral Co., New Johnsonville, Tenn.; Kerr-McGee Chemical Corp., Hamilton (Aberdeen) Miss.; and Union Carbide Corp., Marietta, Ohio. Foote Mineral Co. signed an agreement to become the distributor for the United States and Mexico of the electrolytic manganese metal that will be produced by Delta Manganese (Pty) Ltd., the prospective new producer in the Republic of South Africa.

Ferromanganese.—Bethlehem Steel Co., at Johnstown, Pa., and United States Steel Corp., in the Pittsburg area, continued to be the only domestic ferromanganese producers using blast furnaces. Electric furnaces were used to produce ferromanganese by five other companies in eight plants: Airco Alloys Div., Airco Inc., Calvert City, Ky.; Ohio Ferro-Alloys Corp., Philo, Ohio; Roane Electric Furnace Div. of Woodward Corp., a Division of Mead Corp., Rockwood, Tenn.; Tenn-Tex Alloy Corp. of Houston, Houston, Tex.; and Union Carbide Corp., Ferroalloys Div., Alloy, W. Va., Ashtabula and Marietta, Ohio, and Portland, Oreg. Fused salt electrolysis continued to be used by Chemetals Div., Diamond Shamrock Chemical Co., Kingwood, W. Va., to make low-carbon ferromanganese sold under the trade name of Massive Manganese. U.S. shipments of ferromanganese from furnaces totaled 779,000 short tons compared with 727,000 tons in 1972.

Table 5.—Ferromanganese produced in the United States and manganese ore [1] consumed in its manufacture

Year	Ferromanganese produced			Manganese ore [1] consumed (short tons)		
	Gross weight (short tons)	Manganese content		Gross weight [2]		Per ton of ferromanganese [3] made
		Percent	Short tons	Foreign	Domestic	
1969	852,019	77.3	658,837	1,992,671	8,064	2.3
1970	835,463	78.5	655,436	2,098,210	1,216	2.4
1971	759,896	78.6	597,205	1,820,408	7,033	2.4
1972	800,723	78.3	627,358	1,896,483	25,620	2.3
1973	683,075	78.8	538,119	1,648,806	25,912	2.4

[1] Containing 35% or more manganese (natural).
[2] Includes ore used in producing silicomanganese and metal.
[3] Includes ore used in producing silicomanganese.

Table 6.—Manganese ore used in producing ferromanganese, silicomanganese, and manganese metal in the United States in 1973, by source of ore

Source	Gross weight (short tons)	Mn content, natural (percent)
Domestic [1]	25,912	48
Foreign:		
Africa	674,577	46
Australia	129,749	47
Brazil	511,666	49
India	175,148	44
Mexico	86,472	40
U.S.S.R. [1]	23,013	48
Other or unidentified	48,181	--
Total	1,674,718	47

[1] From U.S. Government surplus stockpile disposals, except for possibly a small tonnage of domestic ore.

Silicomanganese.—Production of silicomanganese in the United States was 184,000 short tons, compared with 153,000 tons in 1972. Shipments from furnaces were 196,000 tons, compared with 146,000 tons in 1972. In 1973, six companies used nine plants to produce silicomanganese: Airco Alloys Div., Airco Inc., Calvert City, Ky., and Theodore (Mobile); Ala.; Interlake Inc., Beverly Ohio; Ohio Ferro-Alloys Corp. Philo, Ohio; Roane Electric Furnace Div., of Woodward Corp., a Division of Mead Corp., Rockwood, Tenn.; Tenn-Tex Alloy Corp. of Houston, Houston, Tex.; and Union Carbide Corp., Alloy, W. Va., Marietta, Ohio, and Portland, Oreg. Consumption of silicomanganese was 14.2% that of ferromanganese, compared with 12.8% in 1972.

Spiegeleisen.—The New Jersey Zinc Co. continued to produce spiegeleisen in electric furnaces at Palmerton, Pa.

Pig Iron.—A total of 354,000 short tons of manganese-bearing ores containing over 5% manganese (natural) was consumed in the production of pig iron (or its equivalent hot metal). Domestic sources supplied 150,000 tons, of which 115,000 tons was manganiferous iron ore containing 5% to 10% manganese, and 35,000 tons was ferruginous manganese ore containing 10% to 35% manganese. Foreign sources supplied 204,000 tons, of which 10,000 tons was manganiferous iron ore, and 194,000 tons contained more than 35% manganese.

Battery and Miscellaneous Industries.—The ore reported in table 3 includes that consumed in making synthetic manganese dioxide by either electrolytic or chemical means, but it does not include consumption of the synthetic dioxide. Although some synthetic dioxide is used for chemical purposes, most of it is used in the manufacture of dry cell batteries, particularly for the manganese-alkaline battery, premium or heavy-duty Leclanché (manganese dioxide-ammonium chloride-zinc) cells, and as a blend with natural ore in the ordinary Leclanché cell.

The domestic ore and much of the foreign ore used for chemical and miscellaneous purposes did not meet national stockpile specification P-81-R for chemical-grade ore.

ESB Inc. purchased the Covington, Tenn. synthetic manganese dioxide plant of Lavino Div., International Minerals & Chemical Corp., and resumed production of electrolytic dioxide late in 1973. The plant had been idle for more than a year. ESB has no plans to resume production of synthetic dioxide by chemical means but has moved its grinding operations for natural battery ores from its Ray-O-Vac dry cell plants to Covington.

The long association of the Lavino name with the manganese business came to an end March 30 when the Lavino Div. (formerly E. J. Lavino & Co.) of International Minerals & Chemical Corp. terminated its business of importing, grinding, and blending battery- and chemical-grade ores.

Kerr-McGee Chemical Corp. increased the capacity of its Henderson, Nev., plant to 8,700 short tons of synthetic manganese dioxide per year, and planned a further increase to 12,000 tons per year by early 1975.

PRICES

Manganese Ore.—All manganese ore prices are negotiated, dependent in part on the characteristics and quantity of ore offered, delivery terms, and fluctuating ocean shipping rates. Trade journal quotations reflect the paper's feel for the market. American Metal Market quotes for metallurgical-grade manganese ore containing 46% to 48% manganese carried over from 1972 at 58 to 61 cents, nominal, per long ton unit, c.i.f. eastern seaboard and Gulf ports. In August, they were increased to 61 to 71 cents, nominal, and carried to the end of the year. The quotations for metallurgical ore containing 48% to 50% manganese were 61 to 64 cents, nominal, at the beginning of 1973, and 74 to 84 cents. nominal, at yearend. The Metals Week quotation for metallurgical-grade manganese ore with a minimum manganese content of 48% carried over from 1972 at 63 to 68 cents, same basis. Although some spot sales were reported as appreciably higher, an increase in June to 68 to 75 cents was credited largely to adjustment for February's devaluation of the dollar. In mid-July, the quote was moved to 75 to 85 cents for a "thin market," in mid-November, to 85 to 95 cents, and in mid-December, to $1.05 to $1.15, at which it closed the year. The last two ranges were a measure of the contract prices that are normally negotiated toward the end of the year.

Manganese Alloys.—The domestic producer price for standard high-carbon ferromanganese having a minimum manganese content of 78% remained at $190 per long ton, f.o.b. producer plant or shipping point, until the middle of April when it was increased $10 to $200 per long ton, same basis, at which price it remained for the remainder of the year. Early in May, Metals Week increased its quote for imported alloy of this grade to $190 to $197 per long ton, delivered in Pittsburgh or Chicago. This remained unchanged to yearend.

Manganese Metal.—The price of standard electrolytic manganese metal held through the first quarter of the year at 33.25 cents per pound, f.o.b. producer plant, for shipments of 30,000 pounds or more. An increase in price of 2 cents became effective for Foote Mineral Co. as of June 1, and earlier for Kerr-McGee Chemical Co. A similar increase announced by Union Carbide Corp. to be effective July 2 was negated by imposition of Government price controls before it could be effected. The result was a dual price, 33.25 and 35.25 cents, for more than half of the year.

FOREIGN TRADE

Ferromanganese exports totaled 8,574 short tons valued at $2,136,917, compared with 6,842 tons valued at $1,511,864 in 1972. Of the 1973 total, Canada took 6,637 tons; Switzerland, 988 tons; Mexico, 309 tons; Dominican Republic, 252 tons; El Salvador, 160 tons; Colombia, 93 tons; Republic of South Africa, 66 tons; Brazil, 31 tons; and six other countries received small quantities. Exports classified as "manganese and manganese alloys, wrought or unwrought, and waste and scrap" totaled 4,660 tons valued at $3,108,688 in 1973. The previous year's exports were 1,504 tons valued at $1,020,743. This classification includes electrolytic manganese metal and manganese-copper alloys, but it does not include ferromanganese. Exports of ore and concentrate containing more than 10% manganese totaled 57,448 tons valued at $4,535,463, compared with 25,108 tons at $3,137,104 in 1972. Most of the 1973 exports were probably imported manganese dioxide ore that may or may not have been subjected to grinding, blending, or otherwise classifying.

The average grade of imported manganese ore was 48% manganese in 1973, compared with 49% in 1972. Brazil supplied 42% of the U.S. total in 1973, while Gabon's portion dropped to 26%. Imports of manganiferous ore (more than 10% but less than 35% manganese) consisted of 110 short tons from Mexico, having an average manganese content of 34%.

Ferromanganese imports for consumption exceeded the previous year's record high, and a good portion of the total continued to come from foreign companies in which U.S. producers or consumers have substantial interest. Silicomanganese imports for consumption totaled 44,759 short tons containing 30,061 tons of manganese. Sources and tonnage (gross weight) were as follows: Norway, 27,882; Yugoslavia, 5,382; Mexico, 4,832; Spain, 3,417; Japan, 1,323; Sweden, 829; France 498; the United Kingdom, 335; and Canada, 261, Imports for consumption classified as unwrought manganese metal, except alloys, and waste and scrap of such metal, totaled 2,452 short tons, compared with 4,121 tons in 1972. Of the 1973 total, 2,100 tons came from the Republic of South Africa, and 352 tons came from Japan. A small quantity, 11 pounds with a value of $132.73 per pound, came from Italy.

Imports for consumption classified as "manganese compounds, other" totaled 4,355 short tons in 1973, compared with 7,937 tons in 1972. The sources, gross weights, and values per pound in 1973 were as follows: Japan, 2,784 tons (19.8 cents); West Germany, 1,123 tons (0.6 cents); Belgium-Luxembourg, 300 tons (17.8 cents); the United Kingdom, 147 tons (6.2 cents); and Sweden, less than half a ton ($1.55). The imports from Japan and Belgium-Luxembourg appear to have consisted largely, if not entirely, of synthetic manganese dioxide.

Tariffs.—Suspension of the duty on manganese ore from most nations, Rate 1, was extended another 3 years (through June 30, 1976) by Public Law 93-99. If duties were in effect, the rate would have been 0.12 cent per pound of contained manganese, the last of the five annual General Agreement on Tariffs and Trade (GATT) reductions effected by Presidential Proclamation 3822 of December 16, 1967. Ore from the U.S.S.R., the People's Republic of China, and certain other specified Communist countries, continued to be subjected to the statutory rate of 1 cent per pound of contained manganese.

Table 7.—U.S. imports [1] of manganese ore (35% or more Mn), by country

Country	1972			1973		
	Gross weight (short tons)	Mn content (short tons)	Value (thousands)	Gross weight (short tons)	Mn content (short tons)	Value (thousands)
Angola [2]	35,570	17,160	$1,244	--	--	--
Australia	82,587	40,261	1,575	123,813	61,458	$2,760
Brazil	[3] 404,972	192,827	8,217	629,833	299,402	15,767
Canada	11	5	(4)	611	354	51
Congo (Brazzaville) [5]	33,521	16,760	64	--	--	--
Gabon [6]	473,142	236,821	10,669	393,037	196,114	10,007
Ghana	46,940	22,062	1,237	38,965	18,601	1,076
India	25,593	12,400	620	--	--	--
Mexico	70,655	32,731	1,803	105,019	41,206	2,616
Morocco	26,309	13,936	1,277	26,427	13,923	1,343
South Africa, Republic of	142,354	65,742	2,715	119,038	55,920	2,002
Zaire [7]	278,598	141,990	4,894	73,050	35,657	1,781
Total	[3] 1,620,252	792,695	34,315	1,509,793	722,635	37,403

[1] Quantities for general imports and imports for consumption were identical.
[2] Part or all of the ore reported to have come from Angola is believed to have originated in Gabon.
[3] It appears that up to 225,000 additional tons (gross weight) may have come from Brazil in 1972.
[4] Less than ½ unit.
[5] Actually from Gabon.
[6] In addition in 1972, Gabon imports reported as Congo (Brazzaville) were approximately 35,000 tons (gross weight), Gabon imports reported as Zaire were approximately 130,000 tons (gross weight), and some or all of the imports reported as Angola probably originated in Gabon.
[7] In 1972, actual imports originating in Zaire were approximately 150,000 tons (gross weight); see footnote 6.

Table 8.—U.S. imports for consumption of ferromanganese, by country

Country	1972			1973		
	Gross weight (short tons)	Mn content (short tons)	Value (thousands)	Gross weight (short tons)	Mn content (short tons)	Value (thousands)
Belgium-Luxembourg	9,911	7,775	$1,172	--	--	--
Brazil	6,079	4,592	667	4,858	3,720	$660
Canada	597	460	211	1,382	1,098	410
France	100,084	78,382	14,067	137,712	106,314	17,803
Germany, West	707	603	267	218	185	96
India	13,093	9,950	1,516	47,242	35,591	5,160
Italy	3,026	2,442	718	--	--	--
Japan	29,050	23,179	5,374	24,264	19,430	5,027
Norway	25,624	20,181	3,145	26,048	20,525	3,561
Rhodesia	1,504	1,210	171	--	--	--
South Africa, Republic of	152,441	120,617	20,866	138,897	109,143	18,200
Spain	--	--	--	5,435	4,367	1,260
Sweden	6,423	5,326	1,672	4,311	3,494	1,131
United Kingdom	(1)	(1)	(1)	--	--	--
Total	348,539	274,717	49,846	390,367	303,867	53,308

[1] Less than ½ unit.

WORLD REVIEW

Under United Nations auspices, a Georgetown, Guyana, April 30 to May 2 meeting of representatives from developing countries was reported to have favored the development of producer associations for different ores including those of manganese. Bauxite, copper, iron, nickel, and cobalt were other likely candidates.

Worldwide interest in deep-sea manganese nodules continued unabated, with the various active groups firming plans for increased testing in 1974. Summa Corp., Houston, Tex., an affiliate of Hughes Tool Co., took delivery of a 618-foot, 36,000-ton surface ship, the Hughes *Glomar Explorer*. A huge 324-foot-long barge, resembling a floating drydock, will be sunk to the ocean floor at a suitable Pacific site. Nodules collected by it from the bottom then will be passed through a pipe to the surface-ship. Tests of the Japanese continuous bucket line (CBL) system of nodule recovery were reported to have met with problems under conditions of rough ocean-floor topography and rapidly changing currents but were reported to have been favorable otherwise.

Argentina.—Manganese ore produced in 1972 had an average manganese content of 28%. Ferromanganese production in 1972 totaled 18,000 short tons compared with 10,000 tons in 1971.

Australia.—The manganese mine of Bell Brothers at Woodie Woodie, Pilbara District, Western Australia, closed. The only other significant producer of manganese ore in Western Australia in recent years, the Longreach group, stopped producing in 1971.[2] Calendar year 1973 production data released by the Minister of Mines of Western Australia, totaled 29,000 short tons as measured by sales realized during the period. The ore was metallurgical ore from the Pilbara District, averaging 48.31% manganese. The mining firm of Hancock and Wright was considering a synthetic manganese dioxide plant at Bunbury, Western Australia. It would use Pilbara manganese ore and ferrous sulfate contained in the effluent from a nearby titanium dioxide plant. Ferric hydroxide would be a product of the plant.

On January 31, 1973, the Australian Minister for Minerals and Energy announced that export controls were being imposed on all minerals to be exported in raw or semiprocessed form. One objective was to encourage more processing in Australia.

Belgium.—Société Europenne des Derives du Manganese (SEDEMA) will increase its synthetic manganese dioxide production capacity to 22,000 short tons per year by the end of 1974. SEDEMA uses the chemical process of the former Manganese Chemicals Corp., Baltimore, Md., now Chemetals Div., Diamond Shamrock Chemical Co.[3]

Brazil.—Production of Amapá mine-run manganese ore in 1973 by Indústria e Comércio de Minerios, S.A (ICOMI) was 2,293,000 short tons. Washed ore produced

[2] Metals Sourcebook. V. 11, No. 1, Jan. 14, 1974, p. 2.
[3] American Metal Market. V. 80, No. 101, May 23, 1973, p. 9.

Table 9.—Manganese ore: World production by country [1]

(Short tons)

Country	Percent Mn [e]	1971	1972	1973 [p]
North America:				
Mexico [2]	35+	294,198	325,867	401,268
United States (shipments)	52	142	578	239
South America:				
Argentina	25–40	15,181	12,330	e 12,000
Bolivia [2 3]	28+	785	103	709
Brazil	38–50	2,868,000	2,268,000	e 2,378,000
Chile	41–47	r 31,788	17,731	15,911
Colombia	NA	496	542	NA
Peru	27–33	r 10,750	12,152	8,574
Europe:				
Bulgaria	30+	45,000	33,000	e 33,000
Greece	50	6,754	5,848	e 5,500
Hungary	30–	r 249,743	206,639	207,257
Italy	30–	33,735	28,260	28,174
Portugal	37–38	r 4,116	5,895	200
Spain	30	r 19,848	14,519	13,643
U.S.S.R. [4]	NA	8,067,000	8,619,000	8,818,000
Yugoslavia	30+	17,762	16,909	10,712
Africa:				
Angola	30+	25,353	41,557	5,161
Botswana	30+	39,246	758	375
Egypt, Arab Republic of	NA	4,716	2,655	e 2,600
Gabon	50–53	2,057,438	2,134,800	2,115,105
Ghana	32–50+	659,800	549,324	350,767
Morocco	53	r 111,836	105,896	161,102
South Africa, Republic of	30+	3,567,666	3,606,205	4,602,839
Zaire	42+	r 362,733	407,283	368,131
Asia:				
Burma	NA	123	308	308
China, People's Republic of [e]	30+	1,100,000	1,100,000	1,100,000
India [5]	10–54	2,029,000	1,810,000	1,692,000
Indonesia	47+	13,181	8,309	17,731
Iran [6]	33+	5,500	e 5,500	e 5,500
Japan	28–45	314,164	287,424	208,113
Korea, Republic of (South)	40	2,495	2,204	1,897
Pakistan	NA	100	140	190
Philippines	52	5,658	2,746	4,379
Thailand	46–50	r 16,901	21,883	40,034
Turkey	35+	14,222	16,620	2,815
Oceania:				
Australia	46–49	1,157,703	1,287,434	1,678,174
Fiji	30–50	8,440	--	--
New Hebrides	43–44	16,537	31,137	NA
Total	NA	r 23,178,110	22,989,556	24,290,408

e Estimate. p Preliminary. r Revised. NA Not available.

[1] In addition to the countries listed, Cuba, Territory of South-West Africa, and Malaysia also may have produced manganese ore and/or manganiferous ore but information is inadequate to make reliable estimates of output levels. Low grade ore not included in this table has been reported as follows in short tons: Czechoslovakia (about 17% Mn) 1971—53,000; 1972—nil; 1973—1,100; Romania (about 22% Mn) approximately 140,000 tons in each year; Republic of South Africa (15%–30% Mn, in addition to material listed in table) 1971—200,220; 1972—112,058; 1973—73,333.

[2] Estimated on the basis of reported contained manganese.

[3] Exports.

[4] Grade unreported. Source: The National Economy of the U.S.S.R., Central Statistical Administration, Moscow.

[5] Of total 1972 output, 57.6% graded below 35% Mn and of total 1973 output 64% graded below 35% Mn, with the balance in each year grading 35% Mn to 48% or more. (Comparable 1971 production breakdown not available, but export figures give 67% below 35% Mn.)

[6] Iranian calendar year beginning March 21 of year stated; all figures apparently are mine run ore.

amounted to 1,744,000 tons having a manganese content of approximately 48%. Production of pellets by the new pelletizing plant, which continued to have problems, was 60,000 tons. Exports of washed metallurgical ore by ICOMI were 1,330,000 tons. Brazil produced 85,000 short tons of ferromanganese and 26,000 tons of silicomanganese in 1973.

Canada.—In the latter part of the year, Union Carbide Canada Ltd. started its new 38,000 kilovolt-ampere closed ferromanganese furnace at Beauharnois, Quebec. It was reported to have a capacity of 100,000 tons of high-carbon ferromanganese per year.[4]

China People's Republic of.—A survey of the People's Republic of China's mineral resources published by the West German Institute for Economic Research concluded,

[4] American Metal Market. V. 80, No. 240, Dec. 12, 1973, p. 16.

with respect to manganese, that of the annual output of 1 million metric tons 90% is consumed domestically and most of the 100,000 tons exported goes to Japan.[5]

Gabon.—Battery and chemical-grade ore produced in 1973 totaled 46,000 short tons.

Ghana.—In September, the Government of Ghana assumed control of all export sales of manganese ore. In November, an agreement was signed with Caemi International, The Hague, the Netherlands, appointing that firm the sole worldwide sales agent for Ghana manganese ore. Caemi International is worldwide sales agent for Brazilian Amapá ore. Ghana ore is marketed in the following grades: Battery grade, containing better than 50% manganese; high-grade lump, containing approximately 49% to 50% manganese; high-grade fines, having a similar manganese content; two lower grades, B and C; and carbonate ore, with a manganese content of approximately 32%. Some of the carbonate ore is used in Europe in electric furnaces for metallurgical purposes, but most of it goes to Japan for use in making synthetic manganese dioxide.

Greece.—An agreement was signed November 8 for construction of a 12,000-ton-per-year synthetic (electrolytic) manganese dioxide plant as a joint venture of two Japanese firms, Tekkosha Co. Ltd. (65%) and Mitsubishi Corporation (35%). Plans called for operation to begin by mid-1975, with a goal to supply the local market and export the balance. Exports of pyrolusite in 1972, apparently battery-grade, totaled 5,700 short tons, of which 2,900 tons went to West Germany and 2,400 tons went to France,

India.—Central Provinces Manganese Ore Co. (C.P.M.O.) continued to operate its one remaining mining property, the Balapur Hamesha (Dongri Buzurg) mine in the State of Maharashtra, although uncertainties surrounded legal status of the property. Although all of the company's remaining ore was apparently sold, the company was hindered in making deliveries by a lack of railway wagons.[6]

The Government of India was reported to have accepted recommendations of the National Committee on Science and Technology (NCST) for construction of a 4,000-short-ton-per-year synthetic (electrolytic) manganese dioxide plant to meet domestic needs. The NCST also was reported to have recommended a plant for manganese metal and for manganese-based chemicals, apparently for export.[7]

To conserve resources and assist in meeting increasing internal demand, the Government of India on April 1 banned the export of First Grade manganese ore (48% or more manganese), except for previous commitments, and decided to reduce exports of Second Grade ores (35% to 48% manganese).

Of the 1,692,000 short tons of manganese ore reported as production for 1973, 1,083,000 tons or 64% was ferruginous ore containing less than 35% manganese, 499,000 tons or 29.5% was classified as Second Grade manganese ore containing 35% to 48% manganese, 108,000 tons or 6.4% was First Grade manganese ore, and 1,700 tons or 0.1% was peroxide ore having a maximum manganese dioxide content of 86%. Exports totaled 814,000 tons divided as follows: Ferruginous, 546,000 tons (all to Japan); First Grade, 37,000 tons (Spain, 18,000; Japan, 13,000; South Korea, 7,000); Second Grade, 230,000 tons (Japan, 190,000; Bulgaria, 14,000; Czechoslovakia, 14,000; South Korea, 12,000); Peroxide, 1,400 (all to Japan). Domestic consumption of manganese ore totaled 826,000 tons, of which 380,000 tons was for ferromanganese production, 430,000 tons for iron and steel, 13,000 tons for dry cell manufacture, and 2,000 tons for miscellaneous uses. Imports were 6,000 tons, presumably all of battery grade.

Production of ferromanganese was 152,000 short tons, compared with 179,000 tons in 1972. Capacity of India's seven plants, all of which produced in 1973, remained unchanged at 215,000 tons. Domestic consumption was approximately 91,000 tons according to preliminary reports from consumers. Exports totaled 60,000 tons, with the United States taking 38,000 tons; Egypt, 18,000 tons; and Japan, 3,700 tons.

Indonesia.—Reported production of manganese ore in 1973 contained more than 75% manganese dioxide.

Iran.—Manganese ore produced in 1972 had an average manganese content of 33%.

Ireland.—Mitsui Denman, Ltd., Irish subsidiary of the Japanese firm Mitsui Mining & Smelting Co. Ltd., contracted

[5] Metals Week. V. 44, No. 35, Aug. 27, 1973, p. 6.
[6] Mining Journal (London). V. 281, No. 7218, Dec. 21, 1973, p. 514.
[7] Mining Journal (London). V. 280, No. 7181, Apr. 6, 1973, p. 275.

with Lummus Co., Ltd. (LCL), for the construction of a $15 million synthetic (electrolytic) manganese dioxide plant on Little Island, County Cork. The plant will use a proprietary Mitsui process and have a productive capacity of 12,000 tons per year, with completion of construction expected by mid-1975. The product will be exported to dry cell manufacturers in the European Common Market. LCL is a London-based affiliate of Combustion Engineering Inc.[8]

Italy.—The manganese ore produced in 1973 averaged 27% manganese content.

Japan.—Tekkosha Co. Ltd. ceased production of electrolytic manganese metal at its 6,000 metric ton per-year Yamagata plant. This dropped the country's annual production capacity to 10,600 from 17,200 short tons.[9] Company plans were to double production capacity of its synthetic manganese dioxide plant at Yamagata to 13,200 short tons per year, reportedly by conversion of the metal facility.[10] Japanese demand for synthetic manganese dioxide in 1973 was 50,000 short tons, of which 33,000 tons was for the export market.[11]

Production of natural dioxide ore or concentrate in 1973 was only 100 short tons, averaging 70% manganese dioxide; metallurgical ore or concentrate produced averaged 28.1% manganese. Production of ferromanganese was 680,000 short tons in 1973 and 610,000 tons in 1972; silicomanganese, 415,000 tons in 1973 and 378,000 tons in 1972; electrolytic manganese metal, 11,111 tons in 1973 and 8,456 in 1972; and synthetic manganese dioxide, 41,338 in 1973 and 43,440 in 1972.

Mexico.—Mexico's principal manganese ore producer, Cia. Minera Autlán, was nationalized through the purchase of the substantial minority interest held by Bethlehem Steel Corp. A $15.5 million loan was obtained from First National City Bank, New York, and construction was to start on a new 50,000-ton-per-year ferromanganese plant near Tampico with the possibility for production to start sometime in 1975. The loan was guaranteed by the State Development Bank, Nacional Financiera, S.A. (NAFINSA). The company's several mines are located in the Molango district of the State of Hidalgo. The deposit from which Autlán has mined battery-grade dioxide ore is approximately 20 miles distant from the larger deposit where its carbonate ore is mined and beneficiated to an oxide nodule for metallurgical use. ESB Incorporated mines battery-grade dioxide ore from a mine in the same part of the district as Autlán's dioxide mine. ESB reports that it has started a calcining operation that will allow the use of lower grade ores than have been mined to date.

Morocco.—All manganese ore produced in 1973 was chemical-grade concentrate having an average manganese dioxide content of 84%.

Philippines.—The manganese ore produced in both 1973 and 1972 was reported to have an average manganese content of 52%.

Portugal.—According to preliminary data, the manganese ore produced in 1973 averaged 37% manganese. In addition, 38,000 short tons of manganiferous iron ore was produced analyzing 42.4% iron and 7.8% manganese.

South Africa, Republic of.—Electrolytic Metal Corp. (Pty) Ltd. (EMCOR) completed its planned expansion of capacity to produce electrolytic manganese metal, and was considering the possibility of a further expansion. Delta Manganese (Pty) Ltd., however, experienced startup problems with its new plant and did not get into production. South African Manganese Ltd., the country's largest producer of manganese ore, reported increased production and shipments, but earnings remained at the same level as those of 1972. High transport costs were largely held responsible for the poor profit showing. In 1972, The Associated Manganese Mines of S.A. Ltd., the second largest producer, made capital expenditures on a new manganese ore mine at NChwaning and on expansion of other manganese mines in the Blackrock area.

Spain.—The manganese ore produced in 1973 had an average manganese content of 30.0%.

Thailand.—Metallurgical-grade manganese ore produced in 1973 was of a 46% to 50% manganese grade, and the battery ore was of a 75% manganese dioxide grade.

Yugoslavia.—Estimated production of ferromanganese in 1973 was 28,000 short tons.

[8] American Metal Market. V. 80, No. 252, Dec. 31, 1973, p. 22.
Metals Sourcebook. V. 11, No. 1, Jan. 14, 1974, p. 3.

[9] Japan Metal Bulletin (Tokyo). June 25, 1974, p. 5.

[10] Metals Sourcebook. No. 23, Dec. 10, 1973, p. 1.

[11] Japan Metal Bulletin (Tokyo). Mar. 12, 1974, p. 5.

TECHNOLOGY

Laboratory investigations of the previously reported sulfatization-reduction modification of the Bureau's high-temperature differential sulfatization process for utilizing low-grade manganiferous iron ores of the Cuyuna Range, Minn., recovered more than 90% of the manganese as an oxide containing 65% manganese, and 75% of the iron as an oxide concentrate containing 60% iron.[12]

In a review of U.S. mineral resources geologists of the U.S. Geological Survey set forth the following among their conclusions: There are virtually no domestic reserves of manganese ore, and known resources are very low grade and refractory; the best possibilities for discovery of domestic reserves or resources of "conventional type" would seem to be in finding the source of the manganese of the Pierre Shale (possibly buried under Pleistocene sedimentary rocks in Minnesota or nearby areas), finding a Molango-type (Mexico) deposit, or finding the source of the manganese that is concentrated in the Salton Sea brines.[13]

The literature on the natural and manmade occurrences of manganese and its biologic effects was critically evaluated by a Panel on Manganese, Div. of Medical Science, National Research Council—National Academy of Sciences. The report was prepared for the Environmental Protection Agency to assist that agency in making its decisions concerning pollutants and their regulation. Average urban ambient-air concentration in the United States for a 12-year period ending in 1965 was approximately 0.10 $\mu g/m^3$; maximum ambient-air concentrations, occuring almost exclusively at industrial locations, exceeded 10$\mu g/m^3$ but were apparently of that order of magnitude. The threshold limit value (TLV) recommended by the American Conference of Governmental Industrial Hygienists is 5 mg/m^3. This is generally believed to constitute a low factor of safety for occupationally-exposed susceptible persons when consideration is given to duration and degree of exposure. However, present concentrations in ambient air would appear to provide a substantial margin of safety for the general population. It does not appear that manganese pollution of water can be expected to be a problem, except locally under very unusual circumstances. The report concludes, "The long-term toxicology of manganese, including fetal effects, still presents a collection of ambiguous answers. For this reason, special care must be exercised before substantial additional sources of manganese are introduced into the environment." The possibility that future widespread use of manganese organometallic fuel additives might create an ambient-air problem requires objective evaluation.[14]

Experimental work under the Environmental Engineering Programs, University of Southern California, Los Angeles, Calif. showed that manganese dioxide has a large adsorption capacity with respect to mercury, up to 10% mercury by weight, provided chloride concentrations are below those of seawater. It was concluded that manganese dioxide might be important as a mercury scavenger in fresh or brackish water, suggesting the possibility for its application to the treatment of waste waters.[15]

A new copper-nickel-zinc-manganese alloy, designated IN629, has been developed by the laboratory of International Nickel Ltd., Birmingham, England. It was claimed that this copper-based spring alloy, analyzing 15% nickel, 13% manganese, and 28% zinc, offers considerable improvement in mechanical properties over copper-nickel-zinc (so-called nickel-silver) alloys that are currently used by the electrical and electronics industries for relay springs. Changes in structure, composition, and annealing treatment gave only small variations in the mechanical properties of the alloy.[16]

Several patents were issued in connection with the Toth process for production of

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[12] Joyce, F. E., Jr., and C. Prasky. Sulfatization-Reduction of Manganiferous Iron Ore. BuMines RI 7749, 1973, 17 pp.

[13] Dorr, J. V. N., M. D. Crittenden, Jr., and R. G. Worl. Manganese. Ch in United States Mineral Resources, U.S. Geol. Survey Prof. Paper 820, ed. by D. A. Brobst and W. D. Pratt, 1973, pp. 385–399.

[14] Division of Medical Sciences, National Research Council—National Academy of Sciences. Medical and Biologic Effects of Environmental Pollutants—Manganese. 1973, 191 pp.

[15] Lockwood, R. A., and K. Y. Chen. Adsorption of Hg(II) by Hydrous Manganese Oxides. Environmental Sci. and Technol., v. 7, No. 11, November 1973, pp. 1028–1034.

[16] Ward, D. M., B. J. Helliwell, and P. J. Penrice. Development of a New Cu-Ni-Zn-Mn Spring Alloy–IN629. Metallurgia & Metal Forming, v. 40, No. 10, October 1973, pp. 319–324.

aluminum metal by the reaction of aluminum trichloride with molten manganese as described in U.S. patent No. 3,615,359, dated October 26, 1971.[17] Basically, the process consists of the chlorination of calcined clay by chemical means, with reduction of the resultant aluminum chloride by manganese metal. The manganese is recycled by oxidation of the manganese chloride generated by the aforementioned reduction step and subsequent reduction of the manganese oxide to manganese metal in a blast or shaft furnace. If both the manganese and the chlorine can be recycled as claimed, the process should be relatively pollution-free; because a thermal reaction is used rather than electrolysis, requirements for electricity should be only one-tenth those of the current Bayer-Hall techniques. Capital costs per ton of aluminum have been estimated 50% to 75% less. Applied Aluminum Research Corp. (AARC), New Orleans, together with Bremar Holdings, London merchant bankers, announced plans for a semicommercial plant to be constructed somewhere in Europe to test the technical and economic feasibility of the process. AARC claimed that costs for a commercial operation would be approximately half of those for producing aluminum electrolytically.[18]

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[17] Toth, C., R. V. Bailey, and H. G. Harris, Jr. (assigned to Applied Aluminum Research Corp.). Process for Producing Aluminum. U.S. Pat. 3,713,809, Jan. 30, 1973, 7 pp.; Can. Pat. 930,175, July 17, 1973, 23 pp.; and Brit. Pat. 1,318,214, May 23, 1973, 9 pp.

Toth, C., and H. G. Harris, Jr. (assigned to Applied Aluminum Research Corp.). Process for Producing Aluminum. U.S. Pat. 3,713,811, Jan. 30, 1973, 8 pp.

[18] Metal Bulletin (London). No. 5814, July 6, 1973, pp. 9-10.

Metals Week. V. 44, No. 8, Feb. 19, 1973, p. 9.

Metals Week. V. 44, No. 28, July 9, 1973, p. 3.

Mercury

By V. Anthony Cammarota, Jr.[1]

Primary mercury production of 2,171 flasks[2] in 1973, valued at $621,405, was the lowest since recordkeeping began in 1850. Of the 24 active mines only five produced over 100 flasks, compared with 12 in 1972. Fourteen mines produced less than 10 flasks each from mined ore, dumps, cleanup operations, or as a byproduct. During the year, only about six mines could be classified as consistent producers.

Secondary production of 10,329 flasks was down from the 1972 level. Some of this material represented mercury released by the General Services Administration (GSA) and some came from the closed mercury-cell chlor-alkali plant of Olin Corp. at Saltville, Va. The company used the mercury at its other plants.

The consumption of 54,283 flasks in 1973 was 2.6% higher than the previous year. Increases were registered for usage in electrical apparatus, electrolytic preparation of chlorine and caustic soda, and industrial and control instruments, but usage in mildew-proofing paint declined.

The average New York price, after falling 59% over the past 4 years to $218.28 per flask in 1972, recovered to $286.23 per flask. Efforts by major mercury-producing countries to establish floor prices apparently were effective in stabilizing prices.

Imports were up sharply from 1972, with Algeria supplying about one-quarter of the total. World production of mercury in 1973 decreased less than 1% from that of 1972, although Spain increased production by 11%.

Government actions during the year included reduction of the mercury objective for the strategic stockpile, the banning of mercury from cosmetics, the promulgation of an air emission standard for mercury plants, and the inclusion of mercury and its compounds in a list of toxic water pollutants.

Legislation and Government Programs.—Government financial assistance on a participatory basis was available for mercury exploration projects through the Office of Minerals Exploration, U.S. Geological Survey, to the extent of 75% of the acceptable costs. No contracts were executed during 1973.

GSA continued its sale of surplus mercury on a sealed-bid basis at the rate of 500 flasks per month. Sales totaled 2,000 flasks, with prices ranging from $302 per flask in January to $268 per flasks in July. Total releases for the year were 2,583 flasks, including 583 flasks transferred to other Government agencies. At the end of the year 4,628 flasks remained available for disposal.

In April, the mercury objective for the strategic stockpile was reduced from 126,500 flasks to 42,700 flasks. A bill (H.R. 7153) was introduced into Congress on April 18 to grant authorization for release of the total surplus of 157,362 flasks, but by yearend no action had been taken. As of December 31, 1973, total strategic stockpile accumulations from all programs stood at 200,062 flasks.

The Food and Drug Administration banned the use of mercury in skin-bleaching preparations and in cosmetics except as a preservative in certain eye-area cosmetics.[3]

The Environmental Protection Agency (EPA) published a national emission standard for mercury applicable to stationary sources that process mercury ore to recover mercury, and to those that use the mercury cell to produce chlorine and caustic soda.[4] Emissions to the atmosphere from each source cannot exceed 2,300 grams (5.1 pounds) of mercury per 24-hour period.

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[1] Physical scientist, Division of Nonferrous Metals—Mineral Supply.

[2] Flask as used throughout this chapter refers to the 76-pound flask.

[3] Federal Register. Use of Mercury in Cosmetics Including Use as Skin-Bleaching Agent in Cosmetic Preparations Also Regarded as Drugs. V. 38, No. 3, Jan. 5, 1973, pp. 853–854.

[4] Federal Register. National Emission Standards for Hazardous Air Pollutants—Asbestos, Beryllium, and Mercury. V. 38, No. 66, Apr. 6, 1973, pp. 8820–8850.

The regulations require that an existing plant must comply with the standard within 90 days after promulgation, unless a waiver is granted. If the Administrator of EPA grants a waiver, a period of up to 2 years for compliance is allowed.

Also, EPA issued a proposed list of toxic pollutants as required by the Federal Water Pollution Control Act Amendments of 1972. Mercury and all its compounds were included. The proposed standards applicable to industrial point sources were designed to protect a variety of water uses.[5] Final guidelines establishing test procedures for the analysis of pollutants were issued by EPA.[6] The approved analytical method for mercury, flameless atomic absorption, must be used when applying for discharge permits or certification by a State. A daily maximum of 0.00014 pound of mercury per 1,000 pounds of product was the proposed limitation set by EPA for the amount of mercury that could be discharged from a mercury-cell chlor-alkali plant after application of the best practicable technology currently available.[7] Another regulation by EPA prohibited the dumping or transportation for dumping of wastes containing more than trace concentrations of toxic materials including mercury and its compounds.[8]

[5] Federal Register. Proposed Toxic Pollutant Effluent Standards. V. 38, No. 247, Dec. 27, 1973, pp. 35388–35395.

[6] Federal Register. Guidelines Establishing Test Procedures for Analysis of Pollutants. V. 38, No. 199, Oct. 16, 1973, pp. 28758–28760.

[7] Federal Register. Proposed Environmental Protection Agency Effluent Limitations Guidelines and Standards of Performance and Pretreatment for Inorganic Chemicals Manufacturing Paint Source Category. V. 38, No. 196, Oct. 11, 1973, pp. 28174–28194.

[8] Federal Register. Environmental Protection Agency Interim Criteria for Evaluation of Permit Applications for Ocean Dumping. V. 38, No. 94, May 16, 1973, pp. 12872–12877.

Table 1.—Salient mercury statistics

	1969	1970	1971	1972	1973
United States:					
Producing mines	109	79	56	r 37	24
Production ____ flasks	29,640	27,296	17,883	r 7,333	2,171
Value ____ thousands	$14,969	$11,130	$5,229	r $1,601	$621
Exports ____ flasks	507	4,653	7,232	400	342
Reexports ____ do	108	50	--	563	--
Imports:					
For consumption ____ do	31,924	21,972	28,449	28,834	46,026
General ____ do	30,848	21,672	29,750	29,179	46,076
Stocks Dec. 31 ____ do	22,692	16,554	16,862	15,708	17,946
Consumption ____ do	77,372	61,503	52,257	52,907	54,283
Price: New York, average per flask	$505.04	$407.77	$292.41	$218.28	$286.23
World:					
Production ____ flasks	289,267	284,014	r 300,634	277,584	276,203
Price: London, average per flask	$536.41	$411.45	$282.46	$203.01	$273.54

r Revised.

DOMESTIC PRODUCTION

Production came from 24 mines in 1973, down from 37 in 1972. Revisions for 1972 added 16 producers to the 21 previously reported in 1972. The additional producers accounted for an increase of 47 flasks in 1972 production; none of the 16 produced more than 10 flasks.

By yearend 1973, six of the largest operations remained active and were expected to continue into 1974. Seven mines reported production exclusively from dumps, cleanup operations, or as a byproduct. An additional 7 mines each showed production of 10 flasks or less. Some exploration and development work was conducted by several small operators. The number of mines reporting outputs of 500 to 999 flasks decreased from four to one, and properties producing 100 to 499 flasks decreased from seven to four. Of the total production of 2,171 flasks, 83% came from producers of over 100 flasks. Principal mines in 1973 were as follows:

State	County	Mine
Properties producing 500 to 999 flasks		
Nevada	Pershing	Red Bird.
Properties producing 100 to 499 flasks		
Alaska	Kuskokwim River Region	White Mountain.
California	Sonoma	Culver-Baer.
Do	Santa Clara	Guadalupe.
Do	do	New Almaden.

California produced 56% of the total mercury production, down from 80% in 1972. New Idria Mining and Chemical Co. sold all its equipment but retained the reduction plant at the New Idria mine in San Benito County, Calif. Until its closing in 1972, the mine was one of the largest producers of mercury with employment of about 160. At the New Almaden property, the company sold all its equipment at auction, and sold six parcels of its 3,500-acre site to Santa Clara County. The company retained three parcels of land on which the Santa Clara Quicksilver Co. operated a mine and a 30-ton-per-day furnace. At the Knoxville mine ore was stockpiled and a small amount of metal was produced from dump material. The Culver-Baer mine closed early in the year and sold its property.

Nevada, with only three mines operating, produced 32% of the total mercury, mostly from the Red Bird mine. In addition, the Carlin Gold Mining Co. continued to recover mercury as a byproduct at its gold mine in Eureka County.

The White Mountain mine in Alaska shipped most of its cinnabar concentrate to Oregon for retorting, but exported a small quantity to the Orient. The Whit-Roy mine in Texas was active for a short time.

The average grade of all ore processed in 1973, including ore treated in concentrators, decreased to 5.9 pounds of mercury per ton. Because of the insufficiency of reported data in 1973, the amount of ore treated and ore grade were based to a large extent on knowledge of producing areas and their historical data.

In spite of a higher level of GSA releases, secondary production of mercury fell to 10,329 flasks from 12,651 flasks in 1972. Dental amalgams, scrap batteries, various types of sludges, mercury from a dismantled chlor-alkali plant, and discarded mercury-containing instruments were the major sources of secondary mercury.

Table 2.—Mercury produced in the United States, by State

Year and State	Producing mines [1]	Flasks	Value [2] (thousands)
1972			
California [r]	30	5,835	$1,274
Idaho	1	161	35
Nevada	3	810	177
Alaska, New York, Texas	3	527	115
Total [r]	37	7,333	1,601
1973			
California	18	1,219	349
Nevada	3	698	200
Alaska, Oregon, Texas	3	254	72
Total	24	2,171	621

[r] Revised.
[1] Mercury mines only.
[2] Value calculated at average New York price.

Table 3.—Mercury ore treated and mercury produced in the United States [1]

Year	Ore treated (short tons)	Mercury produced	
		Flasks	Pounds per ton of ore
1969	432,591	28,552	5.0
1970	424,510	26,795	4.8
1971	265,790	17,444	5.0
1972	[r] 82,580	[r] 7,004	6.5
1973	26,257	2,045	5.9

[r] Revised.
[1] Excludes mercury produced from old surface ores, dumps, and as a byproduct.

Table 4.—Production of secondary mercury in the United States

(Flasks)

Year	Industrial production	GSA releases	Total
1969	10,573	3,077	13,650
1970	7,348	703	8,051
1971	10,899	5,767	16,666
1972	12,139	512	12,651
1973	7,746	2,583	10,329

CONSUMPTION AND USES

Consumption continued to climb for the second consecutive year, to 54,283 flasks. The largest gains were noted for use in electrical apparatus (16%), electrolytic preparation of chlorine and caustic soda (13%), and industrial and control instruments (9%). The use of mercury in batteries, which accounts for the major part of consumption in electrical apparatus, was responsible for much of the increase in that sector. After a 3-year decline, mercury usage in the chlor-alkali industry increased. The major uses for mercury were electrical apparatus (33%), electrolytic preparation of chlorine and caustic soda (24%), mildew-proofing paint (14%), and industrial and control instruments (13%).

Mercury consumption in mildew-proofing paint fell 8% from that of 1972. Although the use of mercurials in paint has not been banned, pending the outcome of a final decision by EPA, it was reported that many companies have switched to new nonmercurial mildewcides. They have done so not only to avoid last-minute reformulation problems, in the event mercurials are banned, but also because laboratory tests have indicated that these compounds could be satisfactory substitutes.

Chlorine production increased 4% to 10.3 million short tons, but only 24.6% of the total was produced in mercury cells, up slightly from 24.2% in 1972. Consumption of mercury per ton of chlorine produced edged up to 0.39 pound from 0.37 pound in 1972. Linden Chlorine Products Inc. reactivated its mercury-cell plant at Linden, N.J. With the closing of the Olin Corp.'s Ecusta plant in Pisgah Forest, N.C., the number of chlorine plants using mercury cells was reduced to 28.

Table 5.—Mercury consumed in the United States, by use

(Flasks)

Use	1969	1970	1971	1972	1973
Agriculture [1]	2,689	1,811	1,477	1,836	1,830
Amalgamation	195	219	--	--	--
Catalysts	2,958	2,238	1,012	800	673
Dental preparations	2,880	2,286	2,361	2,983	2,679
Electrical apparatus	18,490	15,952	16,885	15,553	18,000
Electrolytic preparation of chlorine and caustic soda	20,720	15,011	12,154	11,519	13,070
General laboratory use	1,936	1,806	1,798	594	658
Industrial and control instruments	6,655	4,832	4,871	6,541	7,155
Paint:					
Antifouling	244	198	414	32	32
Mildew-proofing	9,486	10,149	8,191	8,190	7,571
Paper and pulp manufacture	558	226	2	1	--
Pharmaceuticals	712	690	682	578	606
Other [2]	9,134	5,858	2,407	4,258	1,913
Total known uses	76,657	61,276	52,254	52,885	54,187
Unknown uses	715	227	3	22	96
Grand total	77,372	61,503	52,257	52,907	54,283

[1] Includes fungicides and bactericides for industrial purposes.
[2] Includes mercury used for installation and expansion of chlorine and caustic soda plants.

Table 6.—Mercury consumed in the United States in 1973

(Flasks)

	Primary	Redistilled	Secondary	Total
Agriculture [1]	1,819	--	11	1,830
Catalysts	605	--	68	673
Dental preparations	225	1,500	954	2,679
Electrical apparatus	11,673	5,169	1,158	18,000
Electrolytic preparation of chlorine and caustic soda	10,728	--	2,342	13,070
General laboratory use	385	257	16	658
Industrial and control instruments	2,006	3,591	1,558	7,155
Paint:				
Antifouling	32	--	--	32
Mildew-proofing	7,518	--	53	7,571
Pharmaceuticals	276	329	1	606
Other [2]	1,521	252	140	1,913
Total known uses	36,788	11,098	6,301	54,187
Unknown uses	--	57	39	96
Grand total	36,788	11,155	6,340	54,283

[1] Includes fungicides and bactericides for industrial purposes.
[2] Includes mercury used for installation and expansion of chlorine and caustic soda plants.

Table 7.—Stocks of mercury, December 31

(Flasks)

Year	Producer	Consumer and dealer	Total
1969	2,920	19,772	22,692
1970	3,861	12,693	16,554
1971	5,373	11,489	16,862
1972	4,171	11,537	15,708
1973	3,927	14,019	17,946

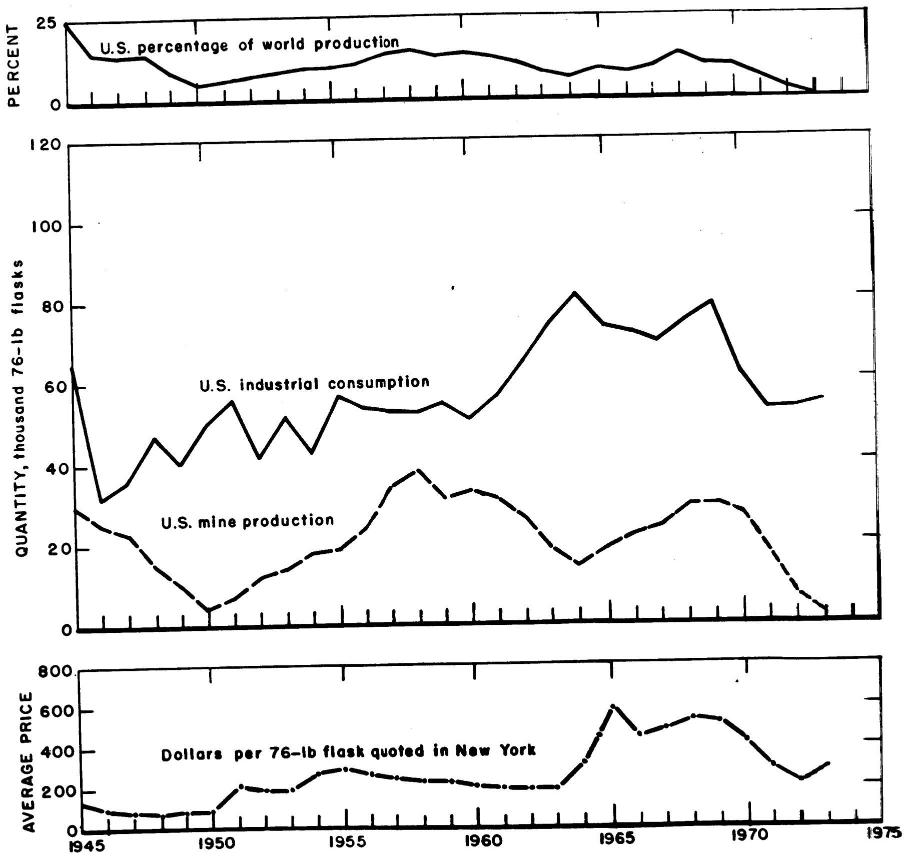

Figure 1.—Trends in production, consumption, and price of mercury.

PRICES

The price of mercury showed signs of settling down from the erratic movements of the past several years. From a January price of $280 to $285 per flask, the price rose to $318 to $330 per flask in late February with the devaluation of the dollar. By midyear the price had fallen to about $250 per flask with the news of a possible stockpile release and the promulgation of emission standards by EPA. In June, prices began an uptrend that reached $310 to $312 per flask in August. The firmer tone was attributed to a hold-back by foreign sources in order to gain greater control over the market. The yearend price was $282 to $288 per flasks. The average price at New York was $286.23 per flask in 1973.

On December 6 the Cost of Living Council amended the phase 4 price regulations on nonferrous metals, thereby removing the price control on mercury. The control was a moot point for mercury because the price during the period never approached the freeze base of $450 to $460 per flask on May 25, 1970.

Although prices on the London market were below New York prices by as much as $24 per flask in October, the gap narrowed by yearend to $5 per flask. Supporting factors for a strengthened foreign market were tenders for mercury from Colombia, India, Taiwan, and Venezuela, and increased Japanese inquiries.

Representatives of the major mercury-producing countries met several times during the year in January, July, and October to exchange views on market developments and to formulate price policies. At the October meeting in Mexico City, Algeria, Italy, Mexico, Spain, Turkey, and Yugoslavia for the first time signed an agreement to pursue market stability by establishing floor prices and selling only to agents that would follow their marketing policy. It was reported that the producers were looking for a minimum price of $280 per flask as a base for future long-term contracts.

Table 8.—Average monthly prices of mercury at New York and London

(Per flask)

Month	1972		1973	
	New York [1]	London [2]	New York [1]	London [2]
January	$213.24	$208.13	$282.50	$260.72
February	207.75	198.84	304.78	289.38
March	185.00	173.39	314.33	303.94
April	152.50	141.36	290.71	283.00
May	171.74	153.25	266.64	257.75
June	196.36	177.39	250.75	243.72
July	211.15	191.12	275.24	263.44
August	245.78	222.50	292.96	274.82
September	255.65	241.11	276.05	266.18
October	254.96	237.78	294.67	270.66
November	256.96	242.75	299.25	286.61
December	269.65	248.50	287.00	282.29
Average	218.28	203.01	286.23	273.54

[1] Metals Week, New York.
[2] Metal Bulletin, London; reported in terms of U.S. dollars.

FOREIGN TRADE

Mercury exports decreased to 342 flasks from 400 flasks in 1972. The major recipients were Canada, the Republic of Korea, and Taiwan.

Imports for consumption, which include mercury imported for immediate consumption plus material withdrawn from bonded warehouses, increased by 60% to 46,026 flasks. General imports, which include mercury imported for immediate consumption plus material entering the country under bond, totaled 46,076 flasks. The major suppliers, who accounted for 88% of the total, were Canada (38%), Algeria (26%), Spain (16%), and Yugoslavia (8%). Included in the import figures are 998 flasks entering the country as secondary metal from Canada and Mexico. Imports of mercury compounds, mainly as mercury cyanide from Japan, were equivalent to 34 flasks of metal.

The U.S. rate of duty on mercury imports during the year was $9.50 per flask.

Table 9.—U.S. exports and reexports of mercury

Year	Exports Flasks	Exports Value (thousands)	Reexports Flasks	Reexports Value (thousands)
1971	7,232	$2,789	--	--
1972	400	129	563	$121
1973	342	170	--	--

Table 10.—U.S. imports for consumption[1] of mercury, by country

Country	1971 Flasks	1971 Value (thousands)	1972 Flasks	1972 Value (thousands)	1973 Flasks	1973 Value (thousands)
Algeria	--	--	3,007	$1,075	11,876	$3,135
Belgium-Luxembourg	2	$2	--	--	5	6
Canada	18,198	5,477	13,803	2,686	17,440	4,748
China, People's Republic of	--	--	--	--	99	29
Colombia	400	101	--	--	--	--
Denmark	--	--	--	--	50	13
Germany, West	203	49	--	--	100	27
Hungary	--	--	100	17	--	--
Italy	250	75	--	--	1,005	260
Japan	3	(2)	2	(2)	--	--
Mexico	4,786	1,160	5,529	941	2,775	710
Netherlands	--	--	53	24	300	84
Norway	--	--	[3] 1,329	305	--	--
Peru	600	155	1,461	310	626	153
Philippines	--	--	100	23	50	15
Spain	2,152	659	1,829	438	7,286	1,834
Sweden	--	--	7	17	7	13
Switzerland	5	8	14	22	6	10
Taiwan	--	--	--	--	40	12
Turkey	1,430	366	450	102	700	174
United Kingdom	--	--	53	13	13	5
Yugoslavia	420	113	1,097	238	3,648	923
Total	28,449	8,165	28,834	6,211	46,026	12,151

[1] General imports in 1971 were 29,750 flasks ($8,500,607), Spain 3,353 flasks ($970,028), Mexico 4,886 flasks ($1,184,826). In 1972, 29,179 flasks ($6,232,570), Peru 2,210 flasks ($458,495), Yugoslavia, 1,402 flasks ($298,345), Spain 1,120 flasks ($254,677). In 1973, 46,076 flasks ($12,164,010), Yugoslavia 3,698 flasks ($935,973).

[2] Less than ½ unit.

[3] Reclaimed metal.

WORLD REVIEW

World mercury production decreased to 276,203 flasks from 277,584 flasks in 1972. Italy, Mexico, Spain, and Yugoslavia accounted for 49% of the total. Mercury producers who met during the year to discuss prices also suggested the possibility of establishing a mercury institute to promote mercury uses and to handle producer marketing.

The Organization for Economic Cooperation and Development (OECD), whose 24 member countries include most of the industrialized non-Communist nations of the world, including the United States, recommended elimination of alkyl mercury compounds in agriculture, elimination of mercury compounds from use in the pulp and paper industry, and maximum possible reduction in discharges of mercury from mercury-cell chlor-alkali plants. In 1973, member countries of OECD produced about 46% of the world total.

The Italian Ministry of Public Health has forbidden entirely the use of organic mercury compounds in agriculture. The Soda Industry Association of Japan revealed a plan to reduce chlorine production from mercury cells from the current 95% down to 60% of the country's capacity. In Canada, mercury cells accounted for 46.8% of total chlorine capacity compared with 60.5% in 1972. On the other hand, the U.S.S.R. is expected to have a 140,000-ton-per-year chlorine plant onstream by 1976 that will use De Nora mercury cells.

Mining operations in Yugoslavia were reviewed.[9]

Table 11.—Mercury: World production, by country

(Flasks)

Country	1971	1972	1973 p
Algeria	7,136	13,361	e 14,000
Australia	9	17	e 20
Canada [1]	18,500	14,600	12,500
Chile	502	640	798
China, People's Republic of e	26,000	26,000	26,000
Colombia	r 193	153	144
Czechoslovakia	5,628	6,614	e 7,000
Finland	135	212	e 220
Germany, West	2,030	2,900	e 5,800
Ireland	2,345	1,250	e 2,000
Italy	42,613	41,801	32,315
Japan	5,564	5,172	3,742
Mexico	35,390	22,510	e 28,000
Peru	r 3,462	3,066	e 3,100
Philippines	5,020	3,341	2,160
Spain	50,831	53,994	60,076
Tunisia	340	238	112
Turkey	10,460	7,963	8,439
U.S.S.R. e	50,000	50,000	52,000
United States	17,883	7,333	2,171
Yugoslavia	16,593	16,419	15,606
Total	r 300,634	277,584	276,203

e Estimate. p Preliminary. r Revised.
[1] Output of Cominco Ltd.; excludes production (if any) by minor producers.

Algeria.—The mercury plant at Ismail produced at full capacity during 1973. A new plant about 50 miles from Annaba was expected to be onstream by the end of 1974.

Canada.—Cominco, Ltd., produced 12,500 flasks, 14% less than in 1972. Ore production at its Pinchi Lake mine amounted to 163,000 tons, compared with 203,000 tons in 1972. Assuming that all the ore mined was treated to produce metal, the ore grade increased from 5.5 pounds of mercury per ton in 1972 to 5.8 pounds in 1973. Ore reserves at yearend were reported by Cominco to be 1,600,000 tons containing 120,000 flasks of mercury. Mining operations at the Pinchi Lake mine, the only mercury mine in Canada, were reviewed.[10]

Italy.—Mercury production fell 23% but exports declined only slightly. Ore grade dropped to 9 pounds of mercury per ton of ore mined, from 10 pounds in 1972. Ore is becoming more difficult and costly to extract as the working levels extend deeper underground. An official Government announcement stated that Italian mines could maintain their present rate of production for another 12 to 15 years.

Lower demand and falling prices in recent years have brought losses to Italian producers, consequently, production was cut to prevent adding to already substantial stocks. Based on production and trade data of the past several years, the apparent mercury stockpile was about 90,000 flasks at yearend.

Spain.—Production increased 11% to 60,076 flasks. Minas de Almadén, the State-owned company, ordered a complete new mercury plant from the U.S.S.R. The plant will be used to process low-grade ore, tailings, and old dump material. Almadén started a 9-month exploration program in the Almadenejos region.

Early in the year, the Spanish Government approved an agreement for the reorganization of the Mieres and Pola de Lena mines in Asturias. The two mines should be able to supply Spain's domestic mercury requirements. To keep the mines in operation, the Government has guaranteed a minimum price for their output.

[9] Bajzelj, U. (The Effects of Mechanization in the Idrija Mercury Mines.) Rudarsko-Metalurski Zbornik, No. 1, 1972, pp. 3-17; translated and published for the U.S. Department of the Interior and the National Science Foundation, Washington, D.C. by the NOLIT Publishing House, Belgrade, Yugoslavia, 1973.

[10] Engineering & Mining Journal. Pinchi Lake: Canada's only mercury mine. V. 174, No. 9, September 1973, pp. 134-135.

Table 12.—Mercury: Exports from Italy, Spain, and Yugoslavia, by country

(Flasks)

Destinations	Italy 1971	Italy 1972 r	Italy 1973 [1]	Spain 1971	Spain 1972	Spain 1973 [2]	Yugoslavia 1971	Yugoslavia 1972	Yugoslavia 1973
Australia	30	--	NA	116	203	348	--	--	NA
Belgium-Luxembourg	752	1,102	522	290	--	145	1	609	NA
Bulgaria	256	--	NA	--	--	--	--	--	NA
Canada	--	--	NA	29	754	87	--	--	NA
Colombia	341	([3])	NA	1,189	290	--	--	--	NA
Czechoslovakia	--	--	NA	--	--	--	840	--	NA
Ecuador	--	--	NA	--	--	--	450	--	NA
France	1,141	609	754	1,711	2,408	1,857	362	290	NA
Germany, East	2,102	--	NA	9,138	2,002	2,843	1	--	NA
Germany, West	5,300	2,002	NA	6,672	3,423	5,047	1,589	493	NA
Greece	10	--	NA	3	29	9	3,081	1,247	NA
Hungary	--	--	NA	--	174	--	--	--	NA
India	--	348	4,670	841	3,278	2,901	--	--	NA
Japan	400	261	493	841	3,539	4,351	--	87	NA
Netherlands	534	290	348	986	377	232	--	--	NA
Poland	921	899	NA	1,508	696	377	300	--	NA
Portugal	350	--	NA	261	145	261	--	--	NA
Romania	1,960	899	NA	--	899	3,887	--	--	NA
South Africa, Republic of	--	--	NA	812	986	348	--	--	NA
Sweden	--	--	NA	2,176	2,175	2,060	210	--	NA
Switzerland	--	145	1,015	348	580	928	600	290	NA
Taiwan	--	--	NA	493	203	232	--	--	NA
United Kingdom	801	3,017	406	1,653	6,759	5,454	1,200	899	NA
United States	250	145	261	3,336	1,044	5,512	5,621	9,486	NA
U.S.S.R	--	--	NA	--	--	--	--	--	NA
Other countries and undistributed	53	[4] 1,218	1,666	234	609	377	30	261	NA
Total	15,201	10,935	10,135	32,637	30,573	37,256	14,285	13,662	13,547

r Revised. NA Not available.
[1] Data for 8 months only.
[2] Data for 9 months only
[3] Less than ½ unit.
[4] Includes 1,015 flasks to Austria.

WORLD RESERVES

Table 13.—Identified mercury resources of the world [1]

(Thousand flasks in ore minable at indicated price per flask)

Country or area	$400	$1,000
North America:		
United States	170	490
Canada	200	400
Mexico	300	700
South America	50	300
Europe:		
Czechoslovakia	15	30
Italy	750	2,000
Spain	2,500	6,000
U.S.S.R	1,000	3,000
Yugoslavia	1,000	2,000
Africa	30	60
Asia:		
China, People's Republic of	1,000	1,500
Japan	60	200
Philippines	50	200
Turkey	60	200
Total	7,185	17,080

[1] Identified resources: Specific identified mineral deposits that may or may not be evaluated as to extent and grade, and whose contained minerals may or may not be profitably recoverable with existing technology and economic conditions.

The U.S. Geological Survey updated its assessment of U.S. and world mercury resources as shown in tables 13 and 14.[11] The Survey stated that at most mercury mines no effort has been made to ascertain the ultimate reserve of the deposit in advance of exploitation. Hence, the total reserves or resources at major world mercury deposits are unknown, but estimates based on production records and geologic information can be made.

[11] Bailey, E. H., A. L. Clark, and R. M. Smith. Mercury Ch. in United States Mineral Resources. U.S. Geol. Survey Prof. Paper 820, 1973, pp. 401-414.

Table 14.—Identified mercury resources of the United States, by State

(Thousand flasks in ore minable at indicated price per flask)

State	$400	$1,000
Alaska	25	100
Arizona	1	6
Arkansas	--	1
California	100	300
Idaho	10	25
Nevada	20	30
New York	5	5
Oregon	5	10
Texas	4	10
Utah	--	1
Washington	--	2
Total	170	490

TECHNOLOGY

A new mineral, balkanite ($Cu_9Ag_5HgS_8$), from the Sedmochislenitsi mine in Bulgaria was reportedly the only known sulfide of copper, silver, and mercury, either as a mineral or as a synthetic product.[12]

Bacteria capable of degrading methylmercury in aquatic sediments were isolated.[13] These organisms may serve a useful purpose in maintaining environmental methylmercury concentrations at a minimum.

Methods for removing mercury from industrial plant effluents and natural waters received widespread attention. Treating solutions containing mercury (II) ions with a starch xanthatepolycation complex, reduced residual mercury (II) content to extremely low levels.[14] Other techniques reported include the absorbtion of mercury on chemically modified cotton cellulose containing amines[15] and by hydrous manganese oxides suspended in solution.[16] Laboratory experiments and small-scale field tests were performed to investigate some possible methods, such as dredging and chemical deactivation, to restore mercury-contaminated lakes and rivers.[17]

A flameless atomic absorption system was developed to analyze ambient mercury levels from 15 nanograms per cubic meter to 10 micrograms per cubic meter by using in-series silver wool collectors.[18] Ambient levels of dimethylmercury, sulfur dioxide, hydrogen sulfide, and nitrogen dioxide did not seriously interfere with the analytical scheme. Another method was described for determining mercury in a variety of matrices including coal and fly ash, which achieves the advantages of a strictly instrumental technique with no chemical manipulations.[19] In a typical coal matrix, the sensitivity is about 10 nanograms of mercury per gram of coal, with a precision of about 10% at 100 parts per billion.

Mercury recovery and recycling processes advanced from the laboratory to the pilot plant or commercial use. Rockwell International Corp. reported excellent results in a pilot plant for removing mercury or other metals from wastewaters using a fluidized bed of conductive particles across which a low-voltage, direct current is applied.[20] Chemical or electrochemical stripping of the metals from the particles can be used to recover the metals and regenerate the bed. The Georgia-Pacific Corp. put into operation at its Bellingham, Wash., chlorine plant a chemical process to reclaim mercury from its effluent.[21] The mercury is recycled back to the mercury cells. The FMC Corp. uses a process at its Squamish, British Columbia, plant to precipitate mercury from the effluent.[22] An extractor solubilizes the mercury in a brine solution, which returns to the plant's mercury cells where elemental mercury is produced and recovered.

At the Bureau of Mines College Park Metallurgy Research Center, a method was developed with the capability of distinguishing between organic and inorganic forms of mercury by using resin-loaded papers.[23] Paper chromatography followed by X-ray spectrography or neutron activation analysis found the mercury content of tap water to be 0.1 to 0.2 part per billion compared with 0.1 to 0.3 part per billion using flameless atomic absorption. The

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[12] Atanassov, V. A., and G. N. Kirov. Balkanite, $Cu_9Ag_5HgS_8$, A New Mineral From the Sedmochislenitsi Mine, Bulgaria. Am. Mineral., v. 58, Nos. 1–2, January–February 1973, pp. 11–15.

[13] Spangler, W. J., J. L. Spigarelli, J. M. Rose, and H. M. Miller. Methylmercury: Bacterial Degradation in Lake Sediments. Science, v. 180, No. 4082, Apr. 13, 1973, pp. 191–193.

[14] Swanson, C. L., R. E. Wing, W. M. Doane, and C. R. Russell. Mercury Removal From Waste Water With Starch Xanthate-Cationic Polymer Complex. Environmental Sci. and Technol., v. 7, No. 7, July 1973, pp. 614–619.

[15] Roberts, E. J., and S. P. Rowland. Removal of Mercury From Aqueous Solutions by Nitrogen-Containing Chemically Modified Cotton. Environmental Sci. and Technol., v. 7, No. 6, June 1973, pp. 552–555.

[16] Lockwood, R. A., and K. Y. Chen. Adsorption of Hg(II) by Hydrous Manganese Oxides. Environmental Sci. and Technol., v. 7, No. 11, November 1973, pp. 1028–1034.

[17] Jernelov, A., and H. Lann. Studies in Sweden on Feasibility of Some Methods for Restoration of Mercury-Contaminated Bodies of Water. Environmental Sci. and Technol., v. 7, No. 8, August 1973, pp. 712–718.

[18] Long, S. J., D. R. Scott, and R. J. Thompson. Atomic Absorption Determination of Elemental Mercury Collected From Ambient Air on Silver Wool. Anal. Chem., v. 45, No. 13, November 1973, pp. 2227–2233.

[19] Weaver, J. N. Determination of Mercury and Selenium in Coal by Neutron Activation Analysis. Anal. Chem., v. 45, No. 11, September 1973, pp. 1950–1952.

[20] Chemical Engineering. V. 80, No. 13, June 11, 1973, p. 78.

[21] Chemical Engineering. V. 80, No. 17, July 23, 1973, p. 61.

[22] Chemical Engineering. V. 80, No. 3, Feb. 5, 1973, p. 27.

[23] Law, S. L. Resin-Loaded Papers for Methyl Mercury and Inorganic Mercury Determination. Am. Lab., v. 5, No. 7, July 1973, pp. 91–93, 96–97.

Bureau of Mines' Reno Metallurgy Research Center, Reno, Nev., published a report describing the electrooxidation process for extracting mercury from cinnabar ore.[24] Power consumption ranged from 10 to 50 kilowatt-hours per ton of ore. Mercury recovery from the pregnant solution was 99.9% pure using 1.5 to 2.0 pounds of zinc and iron, respectively, per pound of mercury contained in solution.

[24] Scheiner, B. J., R. E. Lindstrom, and D. E. Shanks. Recovery of Mercury From Cinnabar Ores by Electrooxidation. BuMines RI 7750, 1973, 14 pp.

Mica

By Benjamin Petkof [1]

For the second time since 1970, there was no reported domestic production of any form of sheet mica. The domestic production of scrap and flake mica continued to rise, and in 1973 output reached the highest ever recorded. Ground mica production increased in both quantity and value. Total exports of mica increased in quantity and value. Imports of processed (including manufactured) and unprocessed (unmanufactured) sheet mica declined in quantity but increased in value. Imports of scrap increased in both quantity and value. The domestic consumption of block and film mica varied little from that of the previous year, but the consumption of mica splittings increased significantly.

Legislation and Government Programs.—During the year, the Government lowered the Defense Material Inventory stockpile objective for all categories of stockpiled sheet mica. The various objectives were reduced as follows: Muscovite block (stained and better), 6 million pounds to 1.6 million pounds; muscovite film (first and second quality), 2 million pounds to 413,000 pounds; muscovite splittings from 19 million pounds to 2.2 million pounds; phlogopite block, 150,000 pounds to 51,000 pounds; and phlogopite splittings, 950,000 pounds to 200,000 pounds. At the end of 1973, the Defense Materials Inventory contained the following quantities of stockpile-grade material: Muscovite block, 10.6 million pounds; muscovite film, 1.4 million pounds; muscovite splittings, 35.8 million pounds; and phlogopite splittings, 4.1 million pounds. The stockpile also contained some nonstockpile-grade material. The General Services Administration continued to dispose of mica from the stockpile.

Table 1.–Salient mica statistics

	1969	1970	1971	1972	1973
United States:					
Sold or used by producers:					
Sheet mica ----------thousand pounds--	W	--	17	14	--
Value ----------thousands--	$3	--	$7	$7	--
Scrap and flake mica ----thousand short tons--	133	119	127	160	177
Value ----------thousands--	$2,893	$2,527	$2,917	$4,353	$6,082
Ground mica ----------thousand short tons--	125	115	120	128	135
Value ----------thousands--	$8,058	$7,350	$8,280	$8,844	$9,401
Consumption, block and film --thousand pounds--	1,498	1,299	1,301	1,207	1,265
Value ----------thousands--	$2,595	$2,058	$2,259	$2,026	$2,106
Consumption, splittings --------thousand pounds--	5,077	5,214	4,177	4,324	5,178
Value ----------thousands--	$2,196	$2,254	$1,818	$1,771	$1,715
Exports ----------thousand short tons--	6	9	8	7	8
Imports for consumption ----------do----	5	6	7	5	6
World: Production ----------thousand pounds--	367,635	360,768	375,554	460,376	525,709

W Withheld to avoid disclosing individual company confidential data.

DOMESTIC PRODUCTION

Sheet Mica.—There was no reported domestic production of any form of sheet mica and the outlook for any future domestic sheet mica mining remained unpromising.

Scrap and Flake Mica.—The production of scrap and flake mica surpassed that of the previous year and reached a new

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alltime high of 177,076 short tons valued at $6,081,893. This was an increase of 11% in quantity and 40% in value. North Carolina retained its position as the largest scrap- and flake-producing State with 60% of total production. The remaining output of scrap and flake mica came from Alabama, Arizona, Connecticut, Georgia, New Mexico, and South Carolina. Flake mica was obtained primarily by the beneficiation of material from pegmatite and clay deposits. The domestic output of scrap and flake was processed into small-particle-sized mica for various industrial end uses.

Ground Mica.—Sales of ground mica increased 5% in quantity and 6% in value over those of 1972. Dry-ground mica accounted for 88% of total sales. Fifteen companies, operating a total of 19 plants, processed scrap and flake mica to a small-particle size; of these plants, 15 produced dry-ground mica; 3 produced wet-ground; and 1 produced both wet- and dry-ground.

Table 2.—Mica sold or used by producers in the United States

Year and State	Sheet mica						Scrap and flake mica[1]	
	Uncut punch and circle mica		Uncut mica larger than punch and circle		Total sheet mica			
	Quantity (pounds)	Value	Quantity (pounds)	Value	Quantity (pounds)	Value	Quantity (short tons)	Value
1969	W	$3,244	--	--	W	$3,244	133,058	$2,893,183
1970	--	--	--	--	--	--	118,843	2,527,450
1971	17,005	6,652	--	--	17,005	6,652	127,084	2,916,879
1972	14,280	7,140	--	--	14,280	7,140	159,536	4,353,313
1973:								
Connecticut	--	--	--	--	--	--	2,504	W
New Mexico	--	--	--	--	--	--	10,200	81,600
North Carolina	--	--	--	--	--	--	106,099	4,422,701
Other[2]	--	--	--	--	--	--	58,273	1,577,592
Total	--	--	--	--	--	--	177,076	6,081,893

W Withheld to avoid disclosing individual company confidential data, included with "Other."
[1] Includes small-particle-size mica derived from feldspar, kaolin, and sericite benefication.
[2] Includes Alabama, Arizona, Georgia, South Carolina, and States indicated by symbol W.

Table 3.—Ground mica sold by producers in the United States, by method of grinding[1]

Year	Dry-ground		Wet-ground		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1969	109,152	$5,486	15,704	$2,572	124,856	$8,058
1970	101,188	5,070	13,905	2,280	115,093	7,350
1971	103,428	5,463	16,176	2,817	119,604	8,280
1972	102,625	5,500	25,649	3,343	128,274	[2] 8,844
1973	119,086	6,406	15,712	2,995	134,798	9,401

[1] Domestic and some imported scrap.
[2] Data may not add to total shown because of independent rounding.

CONSUMPTION AND USES

Sheet Mica.—Consumption of all forms of sheet mica, consisting of block, film, and splittings, showed a significant increase due to greater consumption of splittings, the major form of sheet mica consumed.

Almost 1.2 million pounds of block mica was consumed for the fabrication of vacuum tubes, capacitors, and various other electrical and nonelectrical items. Of the total consumption of block, vacuum tubes required 68% and capacitors accounted for less than 2%. Lower than Stained quality was in greatest demand and accounted for 64% of total consumption; Stained, 36%; and Good Stained or better, the remainder. Only a small quantity of film was consumed, primarily for the fabrication of capacitors.

Muscovite block and film were consumed by 14 companies in 7 States: New Jersey with four consuming plants, New York with three, North Carolina with two, and Pennsylvania with one, consumed 74% of domestically fabricated block and film. The consumption of phlogopite block decreased 6% from 74,199 pounds in 1972 to 69,899 pounds in 1973.

Consumption of splittings increased 20% from that of 1972. India and the Malagasy Republic continued to supply the bulk of the splittings consumed domestically. Splittings were fabricated into various built-up mica products by 11 companies with 12 plants in 7 States. Seven companies with eight plants located in New Hampshire, New York, Ohio, and Pennsylvania consumed almost 4.7 million pounds of splittings or 90% of total consumption.

Built-up Mica.—This mica-based alternate material was produced in various forms, primarily for use as an electrical insulating material. The production of built-up mica products in 1973 increased 21% in quantity and 10% in value from that of the previous year. The forms of built-up mica in greatest demand were molding plate (24%), and segment plate (24%).

Reconstituted Mica.—Three companies continued to manufacture this mica-based alternate material from good-quality delaminated scrap mica. The manufacturing companies were the General Electric Co. at Schenectady, N.Y., the Samica Corp. at Rutland. Vt., and the Acim Paper Corp. at New Hyde Park, N.Y. There were no published data available relating to the quantity and value of the reconstituted mica produced during the year.

Table 4.—Fabrication of muscovite ruby and nonruby block and film mica and phlogopite block mica, by quality and end-product use in the United States in 1973

(Pounds)

Variety, form, and quality	Electronic uses: Capacitors	Electronic uses: Tubes	Electronic uses: Other	Electronic uses: Total	Nonelectronic uses: Gage glass and diaphragms	Nonelectronic uses: Other	Nonelectronic uses: Total	Grand total
Muscovite:								
Block:								
Good Stained or better	877	2,790	2,968	6,635	3,508	15	3,523	10,158
Stained	300	374,869	43,591	418,760	2,514	95	2,609	421,369
Lower than Stained [1]	5,390	426,814	165,976	598,180	17,248	137,827	155,075	753,255
Total	6,567	804,473	212,535	1,023,575	23,270	137,937	161,207	1,184,782
Film:								
First quality	2,557	270	165	2,992	240	--	240	3,232
Second quality	5,766	--	100	5,866	--	--	--	5,866
Other quality	1,050	--	--	1,050	--	--	--	1,050
Total	9,373	270	265	9,908	240	--	240	10,148
Block and film:								
Good Stained or better [2]	9,200	3,060	3,233	15,493	3,748	15	3,763	19,256
Stained [3]	1,350	374,869	43,591	419,810	2,514	95	2,609	422,419
Lower than Stained	5,390	426,814	165,976	598,180	17,248	137,827	155,075	753,255
Total	15,940	804,743	212,800	1,033,483	23,510	137,937	161,447	1,194,930
Phlogopite: Block (all qualities)	--	--	4,148	4,148	--	65,751	65,751	69,899

[1] Includes punch mica.
[2] Includes first- and second-quality film.
[3] Includes other-quality film.

Table 5.—Fabrication of muscovite ruby and nonruby block and film mica in the United States in 1973 by quality and grade

(Pounds)

Form, variety, and quality	Grade					
	No. 4 and larger	No. 5	No. 5½	No. 6	Other [1]	Total
Block:						
Ruby:						
Good Stained or better	2,404	1,762	696	1,794	--	6,656
Stained	13,454	74,066	85,378	226,121	10,970	409,989
Lower than Stained	10,177	86,022	136,072	266,807	188,239	687,317
Total	26,035	161,850	222,146	494,722	199,209	1,103,962
Nonruby:						
Good Stained or better	2,519	68	50	865	--	3,502
Stained	1,621	5,123	1,325	3,311	--	11,380
Lower than Stained	16,250	13,788	880	2,020	33,000	65,938
Total	20,390	18,979	2,255	6,196	33,000	80,820
Film:						
Ruby:						
First quality	852	350	400	325	--	1,927
Second quality	895	1,913	1,608	150	--	4,566
Other quality	--	--	--	--	1,050	1,050
Total	1,747	2,263	2,008	475	1,050	7,543
Nonruby:						
First quality	--	--	580	725	--	1,305
Second quality	--	--	1,300	--	--	1,300
Other quality	--	--	--	--	--	--
Total	--	--	1,880	725	--	2,605

[1] Figures for block mica include all smaller than No. 6 grade and "punch" mica.

Table 6.—Consumption and stocks of mica splittings in the United States, by source country

(Thousand pounds and thousand dollars)

	India		Malagasy		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
Consumption:						
1969	4,799	2,005	278	191	5,077	2,196
1970	5,013	2,109	202	144	[1] 5,214	[1] 2,254
1971	4,084	1,750	93	68	4,177	1,818
1972	4,245	1,658	79	113	4,324	1,771
1973	5,063	1,606	115	109	5,178	1,715
Stocks Dec. 31:						
1969	2,415	NA	145	NA	2,560	NA
1970	W	NA	W	NA	2,013	NA
1971	1,317	NA	98	NA	1,415	NA
1972	1,723	NA	86	NA	1,809	NA
1973	1,246	NA	55	NA	1,301	NA

NA Not available. W Withheld to avoid disclosing individual company confidential data.
[1] Data may not add to totals shown because of independent rounding.

Table 7.—Built-up mica[1] sold or used in the United States, by product

(Thousand pounds and thousand dollars)

Product	1972		1973	
	Quantity	Value	Quantity	Value
Molding plate	851	2,369	1,109	2,274
Segment plate	1,125	2,394	1,105	2,279
Heater plate	W	W	W	W
Flexible (cold)	468	971	683	1,598
Tape	957	3,239	W	W
Other	357	934	1,649	4,718
Total	[2] 3,757	9,907	[2] 4,547	10,869

W Withheld to avoid disclosing individual company confidential data, included with "Other."
[1] Consists of alternate layers of binder and irregularly arranged and partly overlapped splittings.
[2] Data may not add to totals shown because of independent rounding.

Table 8.—Ground mica sold by producers in the United States, by use

Use	1972		1973	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Roofing	18,798	$650	21,582	$792
Wallpaper	492	79	481	73
Rubber	5,589	W	5,719	1,009
Paint	27,115	2,816	37,418	3,392
Plastics	497	96	401	80
Welding rods	W	W	W	W
Joint cement	52,111	3,308	51,116	2,879
Other [1]	23,672	1,894	18,081	1,176
Total	128,274	[2] 8,844	134,798	9,401

W Withheld to avoid disclosing individual company confidential data, included with "Other."
[1] Includes mica used for molded electric insulation, annealing, well drilling, textile and decorative coating, texture paint, and uses indicated by symbol W.
[2] Data does not add to total shown because of independent rounding.

STOCKS

At yearend there was about 2.02 million pounds of sheet mica in fabricators' stocks. Of this quantity, 64% was splittings and the remainder almost entirely block. Only a minor quantity consisted of film. This information was obtained by direct canvass of sheet mica fabricators. Similar information is unavailable for scrap and flake mica, but it is thought that producers maintain stock inventories equal to 5% to 10% of domestic production.

PRICES

The average value of imported muscovite sheet in 1973, based on consumption data, was as follows: Block, $1.63 per pound; film, $5.84 per pound; and splittings $0.33 per pound. The average value of phlogopite sheet mica, also based on consumption data was as follows: Phlogopite block, $1.72 per pound; and phlogopite splittings, $0.95 per pound.

The average value of scrap and flake mica produced during the year was $34.36 per ton. Prices for ground mica, prepared from scrap and flake, quoted in the Chemical Marketing Reporter show slight increases over those of the previous year. Yearend prices are shown in table 9.

Table 9.—Price of dry- or wet-ground mica in the United States in 1973 [1]

	Cents per pound
Dry-ground:	
Joint cement, 100 mesh	4–5
Plastic, 100 mesh	4–5
Roofing, 20 to 80 mesh	2–3
Wet-ground: [2]	
Paint or lacquer, 325 mesh	9½–10
Rubber	9½–10
Wall paper	10½–11

[1] In bags at works, carlots, unless otherwise noted.
[2] Freight allowed east of the Mississippi River.

Source: Chemical Marketing Reporter. V. 204, No. 27, Dec. 31, 1973.

FOREIGN TRADE

All classes of mica exports increased 5% in quantity and 11% in value from that of the previous year. About one-half of the sheet, scrap and flake, and ground mica exported was shipped to Canada, France, and the United Kingdom. Exports of mica manufactures increased in both quantity and value. Reported export data did not provide information on the grade or type of mica exported, but it is assumed the major portion of the material exported was ground mica.

Imports of scrap and waste mica almost doubled from those of the previous year. There were no imports of phlogopite mica. Imports of sheet mica declined 22% in quantity, but increased 9% in value. Processed mica imports declined 15% in quantity and increased 36% in value.

Table 10.—U.S. exports of mica and manufactures of mica in 1973, by country

Destination	Mica, including block, film and splittings, waste and scrap, and ground mica		Manufactured	
	Quantity (pounds)	Value (thousands)	Quantity (pounds)	Value (thousands)
Algeria	879,725	$86	--	--
Argentina	106,819	23	16,414	$54
Australia	133,656	20	48,663	91
Belgium-Luxembourg	165,000	13	44,023	50
Bolivia	148,000	59	--	--
Brazil	--	--	53,697	168
Canada	5,111,006	329	300,742	993
Chad	85,200	11	--	--
Colombia	132,609	20	7,572	17
Denmark	--	--	25,366	151
Dominican Republic	44,000	6	813	2
Egypt	37,700	3	1,894	6
France	1,336,807	93	13,781	57
Germany, West	314,610	48	7,448	8
Guatemala	86,333	10	--	--
Hong Kong	20,110	16	1,732	5
Indonesia	80,000	9	--	--
Iran	103,450	11	248	1
Italy	456,777	103	37,359	125
Jamaica	23,945	2	19,537	28
Japan	851,686	730	159,469	207
Mexico	407,346	36	313,855	786
Netherlands	614,833	41	2,373	16
Norway	--	--	1,562	6
Peru	40,472	4	509	3
Philippines	35,132	7	409	3
Singapore	788,200	86	634	7
South Africa, Republic of	108,005	11	19,280	26
Spain	245,885	31	29,837	104
Sweden	35,580	5	1,632	9
Switzerland	17,527	26	2,520	5
Taiwan	--	--	4,368	39
Trinidad and Tobago	--	--	301	1
United Arab Emirates	376,323	45	553	2
United Kingdom	1,029,422	245	22,711	39
Venezuela	564,746	47	2,896	7
Other	207,560	25	13,654	48
Total	14,588,464	2,201	1,155,852	3,064

Table 11.—U.S. exports and imports of mica

(Thousand pounds and thousand dollars)

Year	Exports		Imports for consumption					
	All classes		Uncut sheet and punch		Scrap		Manufactured	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1971	15,182	3,768	1,355	1,171	7,284	171	4,464	2,476
1972	14,959	4,752	1,494	1,162	2,641	62	5,644	3,183
1973	15,744	5,265	1,169	1,269	5,072	116	4,785	4,325

Table 12.—U.S. imports for consumption of mica, by kind and country

Year and country	Unmanufactured: Waste and scrap: Phlogopite: Quantity (pounds)	Phlogopite: Value (thousands)	Waste and scrap: Other: Quantity (pounds)	Other: Value (thousands)	Block mica: Quantity (pounds)	Block mica: Value (thousands)	Other: Muscovite: Quantity (pounds)	Muscovite: Value (thousands)	Other: Other, n.e.c.: Quantity (pounds)	Other, n.e.c.: Value (thousands)
1971	188,107	$4	7,096,451	$167	989,393	$902	207,945	$54	158,437	$215
1972	112,000	4	2,529,399	58	895,661	946	109,768	4	488,351	212
1973:										
Brazil	--	--	1,300,714	36	720,799	728	44,092	7	56,484	68
Canada	--	--	--	--	--	--	--	--	20,000	2
Hong Kong	--	--	--	--	--	--	--	--	35	6
India	--	--	3,772,198	80	264,561	304	1,594	6	645	35
Malagasy Republic	--	--	--	--	9,301	18	--	--	48,982	74
Tanzania	--	--	--	--	--	--	1,629	15	543	6
Total	--	--	5,072,912	116	994,661	1,050	47,315	28	126,689	191

Year and country	Manufactured: Splittings: Quantity (pounds)	Splittings: Value (thousands)	Not cut or stamped not over 0.006 inch in thickness: Quantity (pounds)	Value (thousands)	Cut or stamped: Not over 0.006 inch in thickness: Quantity (pounds)	Value (thousands)	Cut or stamped: Over 0.006 inch in thickness: Quantity (pounds)	Value (thousands)
1971	4,065,125	1,134	52,271	42	79,711	1,013	113,105	180
1972	4,561,968	1,123	6,572	16	96,116	1,445	105,726	165
1973:								
Austria	--	--	--	--	42	([1])	--	--
Brazil	--	--	4,806	3	--	--	--	--
Canada	2,461	1	--	--	--	--	1,443	6
France	--	--	--	--	940	21	30	1
Haiti	--	--	880	3	2,380	29	--	--
Hong Kong	--	--	--	--	37	1	--	--
India	3,493,874	784	10,028	24	134,328	2,249	129,815	229
Ireland	--	--	--	--	32	1	--	--
Jamaica	300	([1])	--	--	--	--	--	--
Japan	--	--	--	--	1,973	38	--	--
Malagasy Republic	121,144	90	--	--	--	--	--	--
Mexico	--	--	--	--	62	3	35	([1])
South Africa, Republic of	11,023	6	--	--	--	--	653	2
Taiwan	--	--	--	--	761	20	--	--
United Kingdom	--	--	--	--	1,810	49	1,762	22
Total	3,628,802	881	15,714	30	142,365	2,411	133,738	260

Year and country	Mica plates and built-up mica: Quantity (pounds)	Mica plates and built-up mica: Value (thousands)	Ground or pulverized: Quantity (pounds)	Ground or pulverized: Value (thousands)	Article not especially provided for of mica: Quantity (pounds)	Article not especially provided for of mica: Value (thousands)
1971	29,198	32	105,820	2	19,383	73
1972	294,424	274	22,046	([1])	556,984	160
1973:						
Belgium-Luxembourg	466,421	417	--	--	--	--
Brazil	--	--	7,496	1	--	--
Canada	15,772	49	108,003	10	6,306	4
Germany, West	33,336	63	--	--	--	--
India	--	--	108,023	3	17,057	79
Italy	--	--	--	--	865	1
Mexico	--	--	--	--	44	([1])
Netherlands	75,966	68	--	--	311	13
Switzerland	10	1	--	--	213	([1])
Taiwan	22,950	22	--	--	--	--
United Kingdom	--	--	360	([1])	834	12
Total	614,455	620	223,882	14	25,630	109

[1] Less than ½ unit.

WORLD REVIEW

World mica production showed some variation from that of previous years, but the major production of sheet muscovite and phlogopite occurred in India and the Malagasy Republic respectively. The United States remained the major world producer of scrap and flake mica.

India.—The pattern of Indian mica production remained unchanged from the previous year. Production was dependent on output from 100 regularly operated mines. Other mines continued to operate intermittently as small cottage industries with small, individual outputs.

Exports of mica continued under the direct control of the Minerals and Metals and Trading Corp. (MMTC). It is anticipated that the MMTC will endeavor to exert control over the mica industry from production to domestic consumption and export.

Indian mica consumption continued to increase for the manufacture of items such as refractories, rubber products, built-up mica, paints, and electronic and electrical apparatus.

Malagasy Republic.—The country remained the major world source of all forms of phlogopite mica with production of almost 2 million pounds of block, splitings, and scrap during the year. Almost two-thirds of production consisted of splittings; the remainder, block and scrap. Exports of phlogopite mica reached 2.2 million pounds, with splittings accounting for slightly over one-half of the total quantity exported.

Table 13.—Mica: World production by country

(Thousand pounds)

Country [1]	1971	1972	1973 [p]
Argentina:			
Sheet	[r] 353	256	[e] 270
Waste, scrap, etc	[r] 6,823	4,616	[e] 4,600
Brazil [2]	[r] 5,600	5,681	[e] 5,700
Colombia	71	84	[e] 90
France	6,883	[e] 6,800	[e] 6,800
Guatemala	--	2,639	[e] 2,600
India:			
Exports:			
Block [3]	2,915	3,309	1,770
Splittings [4]	13,832	14,235	11,215
Scrap [5]	35,891	38,354	49,743
Domestic consumption, all classes [e]	17,600	18,700	21,200
Total [e]	70,238	74,598	83,928
Malagasy Republic (phlogopite):			
Block	74	127	276
Splittings	978	751	1,248
Scrap	244	413	438
Mexico	1,561	1,821	1,724
Mozambique (including scrap)	2,094	--	--
Norway (including scrap)	7,668	[2] 9,048	[2] 9,672
Portugal	1,786	3,651	[e] 3,700
South Africa, Republic of:			
Sheet	7	4	([6])
Scrap	15,785	9,359	13,248
Sri Lanka	694	428	[e] 400
Tanzania:			
Sheet	[r] 82	40	71
Scrap [e]	29	29	29
United States:			
Sheet	17	14	--
Scrap and flake	254,168	319,072	354,152
U.S.S.R. (all grades)	84,000	86,000	88,000
Yugoslavia	1,221	278	[e] 330
Total	[r] 460,376	525,709	577,276

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition to the countries listed, the People's Republic of China, Romania, Southern Rhodesia, South-West Africa, and Sweden are known to produce mica, but available information is inadequate to make reliable estimates of output levels.

[2] Exports.

[3] Includes micanite and other built-up.

[4] Includes condenser film, washer, and discs.

[5] Includes sheet, strips, and powder.

[6] Less than ½ unit.

TECHNOLOGY

A recent government publication reviewed the resource position of mica and concluded that although the United States had undiscovered and paramarginal resources of sheet mica, the necessary hand labor required to mine and prepare sheet mica deterred any exploration, development, or mining. The report concluded that reserves and resources of flake mica were adequate to meet future demand.[2]

Experimental work was conducted to observe the effect on reinforcement capability of adding mica, which has a high aspect ratio (flake equivalent diameter to thickness ratio), to polystyrene copolymer and polyester resin. Mica flakes with aspect ratios above 100 imparted a high degree of reinforcement to thermoplastic or thermosetting materials under a given set of conditions.[3]

[2] Lesure, F. G. Mica. Ch. in United States Mineral Resources. Geol. Survey Prof. Paper 820, 1973, pp. 415–423.

[3] Lusis, J., R. T. Woodhams, and M. Xanthos. The Effect of Flake Aspect Ratio on the Flexural Properties of Mica Reinforced Plastics. Polymer Eng. and Sci., v. 13, No. 2, March 1973, pp. 139–145.

Molybdenum

By Andrew Kuklis [1]

World molybdenum output increased slightly above that of 1972. Consumption, on the other hand, rose significantly in response to a strong worldwide demand for molybdenum. Consumption exceeded production for the first time since 1965. World industrial inventories of molybdenum declined to 129.8 million pounds or approximately normal requirements.

In response to greater demand for molybdenum, several mines reopened, others resumed producing at capacity, and some expanded mining operations. However, some molybdenum mines remained marginal operations because of low prices resulting from an oversupplied and competitive market. Prices on foreign markets began to improve at midyear and at yearend domestic prices returned to their higher published level.

Table 1.—Salient molybdenum statistics

(Thousand pounds contained molybdenum and thousand dollars)

	1969	1970	1971	1972	1973
United States:					
Concentrate:					
Production	99,807	111,352	109,592	112,138	115,859
Shipments	103,009	110,381	97,882	102,197	135,097
Value	173,819	190,077	164,917	170,530	217,721
Consumption	73,275	76,101	66,399	62,560	82,477
Imports for consumption	(1)	25	854	385	458
Stocks, Dec. 31: Mine and plant	8,398	9,715	29,077	45,243	21,998
Primary products:					
Production	68,526	75,383	67,016	64,841	85,046
Shipments	77,726	76,095	66,654	75,538	108,687
Consumption	51,622	45,337	40,950	45,558	57,049
Stocks, Dec. 31: Producers	17,844	25,904	31,048	28,898	22,387
World: Production	[2] 159,470	181,429	r 171,064	r 174,418	181,152

r Revised.
1 Less than ½ unit.
2 Non-communist countries.

Legislation and Government Programs.—President Nixon signed into law a Congressional bill (S2551) authorizing the General Services Administration (GSA) to dispose of 36.5 million pounds of molybdenum from the national stockpile. Previous legislative action by Congress released 4.3 million pounds of molybdenum for sale. Most of the material will be sold to domestic producers under a long-term buyback contract. Also, GSA was expected to offer approximately 8 million pounds of molybdenum over an extended period, initially on a sealed-bid basis and later (depending on market conditions) on a shelf-item basis.

At yearend, molybdenum in the national stockpile totaled 38.0 million pounds. During the year, GSA sold more than 5.8 million pounds. Approximately 2.9 million pounds of molybdenum was classed as sold but unshipped.

Table 2.—U.S. Government molybdenum stockpile material inventories on Dec. 31, 1973

(Thousand pounds contained molybdenum)

Type material	National (stragetic) stockpile
Molybdenum, disulfide	24,416
Molybdenum, ferro	4,980
Molybdenum oxide	8,651
Total	38,047

1 Mining engineer, Division of Ferrous Metals—Mineral Supply.

Table 3.—U.S. Government molybdenum stockpile material, sold but unshipped on Dec. 31, 1973 [1]

(Thousand pounds contained molybdenum)

Type material	National (strategic) stockpile
Molybdenum, disulfide	1,176
Molybdenum, ferro	227
Molybdenum oxide	1,522
Total	2,925

[1] Not included in table 2.

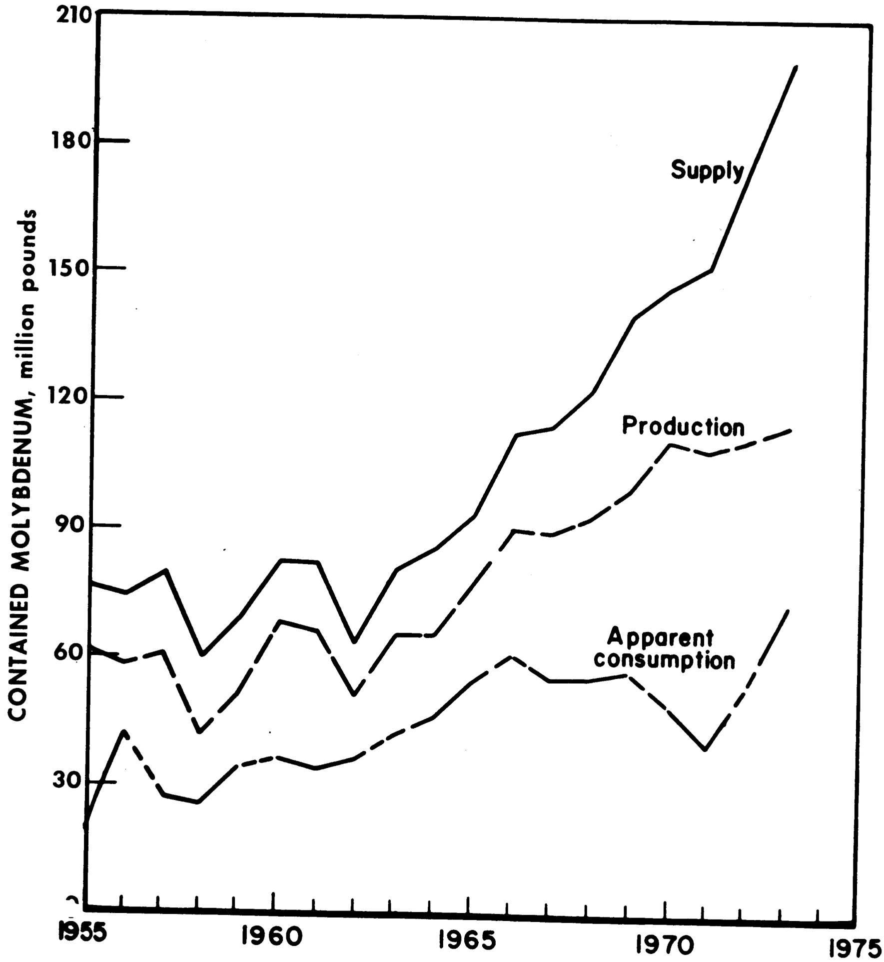

Figure 1.—Apparent consumption, production, and supply of molybdenum in the United States.

DOMESTIC PRODUCTION

Domestic production of molybdenum increased 3.7 million pounds in 1973 and was over 3% higher than in 1972. For the molybdenum producing industry, 1973 was another record year. Higher production rates at byproduct operations accounted for the increased output. Ores processed at concentrators for recovery of molybdenum totaled 204.5 million tons; of which, the bulk was byproduct ores. Mines producing only molybdenum reduced their output over 5% in 1973 compared with 1972 output. Molybdenum output from byproduct sources rose to 42% of total production from the 37% reported in 1972, continuing the upward trend of past years.

Demand for molybdenum was strong during 1973 because of record consumption by the steel industry. Mine and plant inventories were reduced significantly. The domestic molybdenum industry enjoyed continuous operations during 1973 as no serious labor problems interrupted production schedules.

Three mines produced over 67 million pounds of molybdenum from primary ores; of these, two were in Colorado and one was in New Mexico. As in past years, the Climax mine of American Metal Climax, Inc. (AMAX), was the world's largest producer with over 29% of the total.

The 48.8 million pounds of molybdenum produced at byproduct plants increased 18% over 1972 figures. The increase was due to a strong demand for copper and other byproduct minerals. Of the 14 plants processing copper porphyry ore containing molybdenum, 10 increased their output, 3 had lower production, and 1 previously closed plant resumed operating in 1973. The Silver Bell facility of American Smelting and Refining Co. (Asarco) did not recover molybdenum during 1973.

Molybdenum recovered from uranium ores declined 23,600 pounds and that from tungsten ores declined 93,995 pounds compared with 1972 figures.

According to 1973 data, Pennzoil Co., parent company of Duval Corp. and Duval Sierrita Corp., was the leading domestic producer of byproduct molybdenum. Kennecott Copper Corp., with four operations, remained in second place. Other large producers of byproduct molybdenum were, in order of quantity, Magma Copper Co. and Anamax Mining Co. Six companies, four byproduct producers and two primary producers, accounted for over 96% of the United States output of molybdenum, or over 63% of the world's production in 1973.

The marked improvement in demand for molybdenum resulted in increased activities associated with expanding current production facilities, and increased exploration for molybdenum minerals and exploitation of new molybdenum deposits.

Development of an open pit mine at

Table 4.—Production, shipments, and stocks of molybdenum products in the United States

(Thousand pounds contained molybdenum)

	1972	1973	1972	1973	1972	1973
	Molybdic oxide [1]		Metal powder		Ammonium molybdate	
Received from other producers	7,591	10,645	21	200	651	1,681
Gross production during year	95,734	133,615	4,109	4,571	4,539	8,174
Used to make other products listed here	47,800	70,335	472	940	3,484	4,567
Net production	47,934	63,280	3,637	3,631	1,055	3,607
Shipments	55,720	84,353	3,578	3,658	2,738	3,484
Producer stocks, Dec. 31	23,701	17,312	580	586	560	542
	Sodium molybdate		Other [2]		Total	
Received from other producers	200	166	385	1,785	8,848	14,477
Gross production during year	1,116	1,539	14,255	16,154	119,753	164,053
Used to make other products listed here	5	1	3,151	3,164	54,912	79,007
Net production	1,111	1,538	11,104	12,990	64,841	85,046
Shipments	1,149	1,593	12,353	15,599	75,538	108,687
Producer stocks, Dec. 31	292	280	3,765	3,667	28,898	22,387

[1] Includes molybdic oxide, briquets, molybdic acid, and molybdenum oxide.
[2] Includes ferromolybdenum calcium molybdate, phosphomolybdic acid, molybdenum disulfide, pellets, molybdenum pentachloride, and molybdenum hexacarbonyl.

Climax by AMAX was completed by yearend. The initial production rate ranged from 3,000 to 4,000 tons, but was expected to increase eventually to 25,000 tons of molybdenum ore per day. The open pit mine will provide flexibility in operation at the Climax property to meet changing market conditions and offset production losses due to gradual closing of the Urad mine. During 1973, an additional flotation stage was added to the regrind circuit at the Climax mill to improve concentrate grade. Also, it enabled the company's conversion plant to upgrade technical grade oxide products.

AMAX continued development of the Henderson molybdenum mine near Empire, Colo. Major work projects underway in 1973 were driving a haulage tunnel through the Continental Divide and construction of a concentrator. Approximately one-half of the 9.3-mile-long tunnel was completed at yearend. Satisfactory progress was made on the concentrator but its completion was not expected until late in 1974. Production at the Henderson mine was scheduled to begin in 1976 at a rate of about 30,000 tons of ore per day. Ultimately, the mine was expected to produce about 50 million pounds of molybdenum annually.

AMAX mined the 300 millionth ton of molybdenum ore at the Climax operation on January 11, 1973. Published information indicated that more ore had been produced at the Climax mine than at any underground mine in North America. According to production data, the record "ore ton" came from the Phillipson level of the mine, a producing area in operation for over 40 years. The 200 millionth "ore ton" was reached on January 27, 1966, less than 7 years ago. Estimated ore reserves at Climax are considered sufficient to operate the mine for an additional 40 years. To maintain the current underground production rate of 43,000 tons per day, a new 600 level was developed at a cost of over $50 million.

AMAX Specialty Metals Corp., a division of AMAX, announced plans for construction of a molybdenum conversion plant at Fort Madison, Iowa. The facility will produce crystalline ammonium molybdate and derivative products for use in the chemical, metallurgical, and petrochemical industries. Also, the molybdenum conversion plant at Langeloth, Pa., will be modernized. It was estimated that total expenditures for both projects would exceed $25 million.

The Fort Madison facility eventually will be expanded to roast molybdenite concentrate and produce a complete line of molybdenum products. Additional plant capacity will be necessary because of expansion of mining operations at Climax and development of new molybdenum production at the Henderson mine. The Iowa location was selected because of developing markets in the Midwest, availability of railroad and water transportation, and proximity to the company's mining operations in Colorado. Construction of the new Iowa facility and expansion of the existing Langeloth plant were scheduled for completion in 1975.

Cyprus Mines Corp. reported reserves of 100 million tons of ore having an average grade of 0.148% molybdenite at the Thompson Creek deposit near Clayton, Idaho. The company has conducted considerable exploratory work in the area since 1967. To date, an incline to the ore body and extensive footage of drifts and crosscuts were completed. Company officials approved additional expenditures of $1.3 million for continuation of development and related work on the deposit. Final studies were underway to determine the economic potential of the deposit at mining rates of 20,000 tons per day and upward. An estimated $70 to $75 million would be required to develop the deposit.

The Esperanza copper-molybdenum mine of Duval Corp. near Tucson, Ariz., resumed production in January. Operations were suspended at yearend 1971 because of mounting inventories of copper and molybdenum concentrate. A cutback in smelter throughput by Asarco, processor of Duval's copper concentrate, caused the accumulation of a large inventory of copper concentrate which contributed to the mine shutdown. The inventory was reduced to manageable levels by exports of 36,000 tons of copper concentrate to foreign markets, principally Japan. Employment of approximately 350 workers was expected to have a beneficial effect on the area's economy. Modification in processing at the concentrator was completed during shutdown and resulted in a 25% increase in throughput.

Molybdenum output at the operations of

Duval Sierrita Corp. rose 22% over that of 1972. Molybdenum recovery was expected to continue to increase in 1974. Throughput of 89,000 tons of ore per day was reached in the concentrator during December, an increase of 5,000 tons compared with previous months of 1973.

Molybdenum Corp. of America (Molycorp) terminated about 20% of its work force at the Questa mine early in the year. It was the second cutback in employment at the facility in 2 years. The first cutback was in July 1971 when the firm laid off 250 workers. Curtailment of production effected approximately 100 employees, principally open pit miners. The concentrator was expected to operate at current production levels. Management stated that the weakness in demand for molybdenum had resulted in low prices for the mineral and related products and subsequently rising inventories at the plant.

CONSUMPTION AND USES

Domestic consumption of molybdenum in concentrate form increased 32% compared with that of 1972. The 82.5 million pounds consumed was the highest on record and exceeded the previous high in 1968 by nearly 7 million pounds. Virtually, all the concentrate consumed was converted to molybdic oxide at plants in Arizona, Colorado, New Jersey, Ohio, Pennsylvania, and Utah. A small quantity of the concentrate was used in producing purified molybdenum disulfide for lubricant purposes; output of purified molybdenum disulfide increased for the second consecutive year.

Domestic consumption of molybdenum materials by end uses rose significantly in 1972 (table 5). The 25% increase over 1972 figures was the highest reported since 1959. Consumption increased because heavy demand for capital goods resulted in higher production levels for general purpose alloy, stainless and tool steels. Molybdic oxide accounted for over 68% of the molybdenum products consumed in 1973 compared with 66% in 1972. The remaining molybdenum products were ferromolybdenum (18%), ammonium and sodium molybdate (2%), and other molybdenum materials (12%).

Of the reported consumption 70% was used in steel production, 8% was used in cast irons, 5% in super alloys, 3% in alloys, and 5% in mill products such as

Table 5.—Consumption of molybdenum materials, by end use in 1973

(Thousand pounds contained molybdenum)

End use	Molybdic oxides	Ferro-molybdenum [1]	Ammonium and sodium molybdate	Other molybdenum materials [2]	Total
Steel:					
Carbon	1,117	265	--	17	1,399
Stainless and heat resisting	6,400	1,965	--	111	8,476
Full alloys	19,813	1,538	--	245	21,596
High-strength low-alloy	2,290	417	--	10	2,717
Electric	498	110	--	--	608
Tool	3,661	1,303	--	28	4,992
Cast irons	904	3,329	--	137	4,370
Superalloys	1,217	479	--	1,363	3,059
Alloys (exclude steels and superalloys):					
Welding and alloy hard-facing rods and materials	W	313	--	36	349
Other alloys [3]	79	646	--	176	901
Mill products made from metal powder	--	--	--	2,997	2,997
Chemical and ceramic uses:					
Pigments	731	--	495	23	1,249
Catalysts	1,707	--	634	--	2,341
Other	57	2	10	990	1,059
Miscellaneous and unspecified	359	138	45	394	936
Total	38,833	10,505	1,184	6,527	57,049
Consumer stocks Dec. 31	4,482	2,209	193	1,242	8,126

W Withheld to avoid disclosing individual company confidential data, included in "Miscellaneous and unspecified."

[1] Includes calcium molybdate.

[2] Includes purified molybdenum disulfide, molybdenite concentrate added directly to steel, molybdenum metal powder, molybdenum metal pellets, and other molybdenum materials.

[3] Includes magnetic and nonferrous alloys.

sheet, rod, and wire. The chemical industry consumed 8% for use in making pigments, catalysts, and other uses.

Research was continued in an effort to develop new uses for molybdenum products such as catalysts for car emission controls and coal gasification. Other new applications of molybdenum under investigation included high-strength steels for stronger automobile bumpers and oil well casing in drill holes of great depth, and an improved super alloy for aircraft and industrial gas turbine engines.

Since 1971, over 200,000 tons of high-strength steel containing molybdenum have been consumed to manufacture oil and gas transmission pipe for service in geographical areas of subzero temperature. With new pipeline projects scheduled in Alaska and the U.S.S.R., a market estimated at 20 million pounds of molybdenum was projected for this requirement in the next decade.

STOCKS

The industrial inventory of molybdenum in concentrate and compounds totaled 52.5 million pounds, 34% less than at yearend 1972. Molybdenum in stocks at mines dropped 51%, those at producer plants decreased 23%, but those at consumer plants increased 66% compared with 1972 figures.

PRICES

Published prices for high-quality molybdenum concentrate and compounds, which were established in May 1969, remained unchanged throughout the year. Because there was some discounting in 1972, domestic producers announced at year end resumption of sales at published prices. The Cost of Living Council removed molybdenum from price control on December 7, 1973. The following tabulation shows published domestic prices at yearend 1973 for molybdenum and related products per pound of contained molybdenum:

Climax concentrate	$1.72
Byproduct concentrate	1.40–1.65
Climax oxide/bags	1.91
Climax oxide/cans	1.92
Dealers oxide	1.86
K–1 oxide	1.78
K–2 oxide	1.71
Ferromolybdenum (Climax lump)	2.21
Ferromolybdenum (Climax powder)	2.27
Ferromolybdenum (Dealer)	2.10

Source: Metals Week, Dec. 31, 1973.

FOREIGN TRADE

U.S. exports of molybdenum concentrate and oxide were the highest on record and exceeded the previous record high in 1969 by 28%. The Nation shipped to foreign markets an equivalent of 64% of the 1973 domestic output, principally to industrialized countries of the world. The 1973 record high in exports was due to an increase in world demand and relatively low prices for U.S. products on foreign markets caused by the de-valued and downward floating dollar.

The Netherlands again was the principal recipient, receiving over 40% of the total. Most of the material entering the Netherlands was converted to other molybdenum products and re-shipped to other European countries.

Ferromolybdenum valued at $3.2 million was exported to 16 countries; Japan received nearly 61% of total value of shipments. Other molybdenum materials exported included metal and alloys in crude form and scrap, wire, powder, and semifabricated forms. Total value of this material was reported at $5.2 million, significantly higher than in 1972.

U.S. exports are summarized in tables 6, 7, and 8.

Table 6.—Molybdenum reported by producers as shipments for export from the United States

(Thousand pounds contained molybdenum)

Product	1972	1973
Molybdenite concentrate	34,390	48,529
Molybdic oxide	14,577	38,471
All other primary products	1,541	2,851

Table 7.—U.S. exports of molybdenum ore and concentrates (including roasted concentrates), by country

(Thousand pounds contained molybdenum and thousand dollars)

Country	1972		1973	
	Quantity	Value	Quantity	Value
Argentina	8	16	36	70
Australia	117	196	354	531
Austria	389	638	--	--
Belgium-Luxembourg	3,708	5,990	6,017	9,799
Brazil	359	612	947	1,621
Canada	386	714	1,364	2,205
Czechoslovakia	130	234	--	--
France	1,123	1,595	1,585	2,533
Germany:				
East	--	--	162	236
West	5,212	7,172	8,892	12,517
India	35	53	136	150
Italy	598	1,020	950	1,606
Japan	9,113	14,302	13,113	22,264
Mexico	405	569	690	939
Netherlands	19,207	32,743	29,888	50,754
New Zealand	28	41	15	22
Philippines	3	7	11	17
South Africa, Republic of	114	178	190	317
Spain	18	29	45	87
Sweden	2,013	3,245	4,611	6,849
Switzerland	(1)	1	584	630
United Kingdom	2,199	3,372	4,207	6,948
Venezuela	185	292	149	269
Other	12	20	12	23
Total	45,362	73,039	73,958	120,387

1 Less than ½ unit.

Table 8.—U.S. exports of molybdenum products

(Thousand pounds, gross weight, and thousand dollars)

Product and country	1972		1973	
	Quantity	Value	Quantity	Value
Ferromolybdenum: [1]				
Argentina	62	83	126	165
Australia	130	175	116	155
Brazil	40	58	70	97
Canada	74	149	220	309
Germany, West	186	183	--	--
India	11	16	--	--
Japan	81	64	1,356	1,920
Netherlands	7	9	13	26
Philippines	7	10	2	3
South Africa, Republic of	75	102	125	195
Sweden	220	290	88	110
Taiwan	--	--	7	9
Thailand	--	--	82	131
Other	16	24	19	31
Total	909	1,163	2,224	3,151
Metal and alloys in crude form and scrap:				
Belgium-Luxembourg	3	9	--	--
France	4	17	1	5
Germany, West	3	16	6	3
Japan	23	39	131	192
South Africa, Republic of	8	51	4	27
United Kingdom	45	58	2	11
Other	3	9	4	14
Total	89	199	148	252
Wire:				
Argentina	4	29	4	28
Australia	13	79	10	62
Austria	2	19	--	--
Belgium-Luxembourg	--	--	17	103
Brazil	18	198	21	239
Canada	30	322	48	418

See footnote at end of table.

Table 8.—U.S. exports of molybdenum products—Continued

(Thousand pounds, gross weight, and thousand dollars)

Product and country	1972 Quantity	1972 Value	1973 Quantity	1973 Value
Wire—Continued				
Finland	1	11	(2)	10
France	32	214	70	479
Germany, West	14	108	72	525
India	1	5	1	5
Italy	5	32	8	55
Japan	32	195	52	362
Mexico	8	133	7	161
Netherlands	--	--	5	160
Philippines	1	26	1	34
Singapore	1	6	(2)	7
Spain	(2)	4	22	153
United Kingdom	11	150	15	269
Other	(2)	20	4	35
Total	173	1,551	357	3,105
Powder:				
Canada	3	12	10	33
France	2	16	3	11
Germany, West	5	16	3	11
Italy	1	4	(2)	1
Japan	(2)	1	125	428
Netherlands	--	--	3	11
Spain	--	--	5	9
Sweden	30	114	41	145
Switzerland	9	21	1	3
United Kingdom	(2)	2	2	7
Other	(2)	6	2	13
Total	50	192	195	672
Semifabricated forms, n.e.c.:				
Australia	2	17	4	30
Belgium-Luxembourg	(2)	2	3	22
Brazil	1	2	6	46
Canada	12	106	22	153
France	9	109	4	102
Germany, West	4	41	4	37
India	18	13	(2)	1
Italy	6	30	4	31
Japan	4	51	38	191
Mexico	10	18	1	18
Netherlands	64	231	69	264
South Africa, Republic of	29	185	(2)	15
Sweden	--	--	16	84
Switzerland	(2)	4	(2)	1
Taiwan	2	13	2	15
United Kingdom	18	152	23	159
Other	2	13	13	47
Total	181	987	209	1,216

1 Ferromolybdenum contains about 60% to 65% molybdenum.
2 Less than ½ unit.

Although the Nation is self-sufficient in molybdenum materials, a small quantity of concentrate, manufactured molybdenum products, and waste and scrap enters the United States from numerous countries throughout the free world. High tariff rates preclude the importation of such materials in large quantities.

Molybdenum concentrate containing 458,315 pounds of molybdenum valued at $962,904 was received from three countries, namely, Canada, Peru, and France. Canada supplied nearly all the material. The gross weight of scrap imported from six countries totaled 94,961 pounds, valued at $197,424. The Netherlands supplied nearly 35% of the valued shipments. Imports of 36,400 pounds (gross weight) of wrought and unwrought metal valued at $373,935 came from nine countries. Austria and Sweden were the principal suppliers.

Molybdenum chemicals and related products entering the United States include ammonium molybdate containing 395,577 pounds of molybdenum valued at $826,481; molybdenum compounds containing 297,760 pounds of molybdenum valued at $614,066; potassium molybdate containing 115 pounds of molybdenum valued at $1,404; mixtures of inorganic compounds containing 2,586 pounds of molybdenum valued at $23,134; and molybdenum orange totaling 1,062,721 pounds, valued at $528,690.

WORLD REVIEW

No official statistics were available on molybdenum output in the U.S.S.R., the People's Republic of China, and other Communist nations, but estimates for those countries were included in the world total in table 9. Non-communist world production of 158.8 million pounds was principally from the United States (73%), Canada (17%), Chile (8%), with Japan and Peru accounting for virtually all the remainder.

Australia.—Mt. Arthur Molybdenum NL conducted geological exploration on mineral leases in Queensland. Also, the company obtained a prospecting lease in the Westmoreland district and exploratory work was underway. The Wolfram Camp facility processed some tungsten-molybdenum ores during the year.

Canada.—Molybdenum output increased 3 million pounds in 1973 and was 10% over that of 1972. A higher production rate at the Endako mine and completion of the first full year of operation at two byproduct molybdenum mines accounted for most of the rise in Canadian output. Record yearend 1972 stocks estimated at 20 million pounds were reduced over 50% in 1973.

Canada ranked second to the United States among world producers of molybdenum and supplied approximately 15% of 1973 world production, an increase of 1% over that of 1972.

Improvement in the world molybdenum demand situation resulted in reopening of mines, expansion of existing operations, and active exploration programs, principally in British Columbia. A number of geological reports describing molybdenum mineralization in Canada and the western Cordilleran Belt of North and South America were published.[2]

Gibraltar Mines Ltd., a subsidiary of Placer Development Ltd., completed the first full year of operation at its copper-molybdenum mine near McLeese Lake, British Columbia. The concentrator processed over 15 million tons of ore from which 122 million pounds of copper and one-half million pounds of molybdenum were recovered. The average daily throughput at the mill was 41,300 tons com-

[2] DeGeoffroy, J., and T. K. Wignall. Statistical Models for Porphyry-Copper-Molybdenum Deposits of the Cordilleran Belt of North and South America. Can. Min. and Met. Bul., v. 66, No. 733, May 1973, pp. 84–90.

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Petruk, William. The Tungsten-Bismuth-Molybdenum Deposit of Brunswick Tin Mines Ltd.: Its Mode of Occurrence, Mineralogy and Amenability to Mineral Beneficiation. Can. Min. and Met. Bul., v. 66, No. 732, April 1973, pp. 113–130.

Table 9.—Molybdenum: World mine production by country

(Thousand pounds contained molybdenum)

Country [1]	1971	1972	1973 [p]
Australia [e]	130	130	130
Bulgaria [e]	310	310	310
Canada (shipments)	22,663	24,493	27,450
Chile	13,935	13,045	12,974
China, People's Republic of [e]	3,300	3,300	3,300
Japan	613	494	346
Korea, Republic of	231	110	112
Mexico	174	172	90
Norway	[r] 725	414	289
Peru	1,782	1,712	1,592
Philippines	9	--	--
U.S.S.R.[e]	17,600	18,100	18,700
United States	109,592	112,138	115,859
Total	[r] 171,064	174,418	181,152

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition to the countries listed, Argentina, North Korea, Nigeria, Romania, South-West Africa, and Spain also produce molybdenum, but information is inadequate to make reliable estimates of output levels.

pared with 39,500 tons in 1972. The installation of automatic control systems on three grinding circuits accounted for improved concentrator throughput.

Additional mining equipment was placed in service to compensate for increasing stripping ratio and haulage distance. Ore was mined principally from the Gibraltar East Stage Pit. Development of the Granite Lake Stage Pit was continued during the year. The project included removal of overburden by a contractor, drainage of a nearby lake, and dredging of nearly 1 million cubic yards of silt. Mine production at the Granite Lake Stage Pit was scheduled to start at midyear 1974.

Lornex Mining Corp. Ltd. completed the first full year of operations at its open pit copper-molybdenum mine, 33 miles south of Ashcroft in the Highland Valley area, British Columbia. Approximately 14 million tons of ore was processed at the concentrator. The milling rate averaged over 38,000 tons daily. Molybdenum output amounted to nearly 3.5 million pounds. The molybdenum concentrate was sold to Phillip Brothers, New York, a division of Engelhard Minerals & Chemicals Corp. Ore reserves were estimated at 292.8 million tons averaging 0.42% copper and 0.014% molybdenite. A report describing the unique operation was published.[3]

Bethlehem Copper Corp. Ltd. spent $3.6 million for a detailed engineering study of the J-A copper-molybdenum ore deposit, 25 miles southeast of Ashcroft also in the Highland Valley area of British Columbia. The deposit is in close proximity to the company's existing copper mine and milling operations. The study recommended a mining operation having a capacity of 25,000 tons of ore per day. An estimated $60 million would be required to develop the ore body. The deposit contains proven ore reserves totaling 286 million tons having an average grade of 0.43% copper and 0.017% molybdenite. The mine was scheduled for production in 1976.

At midyear, operation of the Endako mine, Placer Development Ltd., reached designed capacity of 15 million pounds of molybdenum per year. The mine operated at reduced capacity since August 1971 because of an oversupply of molybdenum. The return to full production resulted in employment of 70 additional workers hence increasing the work force to over 400 employees. Additional production equipment was placed in service at the facility to improve metallurgical recovery and increase roasting and mining capacity. An expansion program at the facility will be continued during 1974 and 1975. Proven and probable ore reserves at the Endako pit at yearend 1973 totaled 153 million tons grading 0.143% molybdenite and at the adjacent Denak pit 21 million tons grading 0.159 molybdenite. At yearend, the company announced an intensive exploration program for 1974 in order to increase molybdenum reserves.

The Endako concentrator processed 8.4 million tons of ore from which nearly 12 million pounds of molybdenum was recovered. Approximately 8.5 million pounds of molybdic oxide was produced at the roasting plant. The company reported inventory of molybdenum at yearend totaling 5.7 million pounds, a decline of 2.2 million pounds from yearend 1972.

Highmont Mining Corp. Ltd., operated by Teck Corp. Ltd., continued development of copper-molybdenum mineralization in the Highland Valley district of British Columbia. The deposit will be developed as two open pit mines and will produce at a rate of 25,000 to 27,000 tons of ore per day. Mineralization extends close to the surface, hence overburden removal costs were expected to be minimal. The deposit contains an estimated 150 million tons of ore having an average grade of 0.28% copper and 0.051% molybdenite. Pilot plant testing of the ore in 1968 resulted in metallurgical recoveries of 92% for copper and 83% for molybdenum. An estimated $70 million was expected to be spent on the mine and concentrator facility.

Hecla Operating Co. Ltd., Canadian exploration subsidiary of Hecla Mining Co., U.S.A., continued exploration and metallurgical testing at the Liard-Schaft Creek copper-molybdenum deposit owned by Silver Standard Mines Ltd. in northwestern British Columbia. Work projects underway and/or completed during 1973 included additional exploratory drilling, bulk sampling, and pilot plant testing of ore. Also, a road was constructed to the property. A detailed feasibility study also was prepared to ascertain the economic potential of the

[3] Mamen, Chris. Lornex–300M Tons on Tap. Can. Min. J., v. 94, No. 8, August 1973, pp. 23–26.

deposit at a mining rate of 25,000 to 40,000 tons per day. The deposit contains an estimated 300 million tons of ore grading 0.40% copper and 0.036% molybdenite.

Brynnor Mines Ltd., a subsidiary of Noranda Mines Ltd., was expected to reopen the Boss Mountain molybdenum mine early in 1974 because of increasing worldwide demand for the mineral. The mine, located near Williams Lake, British Columbia, commenced production in May 1965. The mill was designed to process ore at a rate of 1,700 tons per day. Owing to an oversupply of molybdenum in the early 1970's, the mine suspended production on December 3, 1971. Mine production for the last year of operation totaled 534,500 tons of ore from which over 2 million pounds of molybdenum was recovered. At yearend 1971, ore reserves were reported at nearly 3 million tons, having an average grade of 0.40% molybdenite.

Deep Grid Analysis Ltd. conducted detailed geophysical exploration of two molybdenum targets in the St. Lawrence area, Newfoundland. A systematic drilling program was planned to evaluate positive vibrations received during the study. The molybdenum targets, buried under Pleistocene sediments, cover an area of about 500 acres. Results of soil sampling conducted in past years inferred the presence of significant molybdenum mineralization in the area. Funds for additional investigative work was authorized by Radex Minerals Ltd., owner of the property.

Climax Molybdenum Corp. of British Columbia, subsidiary of AMAX, U.S.A., conducted a feasibility study on the Ruby Creek molybdenum deposit near Atlin, British Columbia, owned by Adanac Mining & Exploration Ltd. Work completed in 1973 included two diamond drill holes totaling 5,000 feet, relogging split cores of previous drilling projects, and collection of rock specimen for thin section and petrographic study. One hole drilled to a depth of 3,000 feet showed good molybdenum for the first 600 feet. The other hole drilled to a depth of 2,000 feet had molybdenum mineralization between 170 and 420 feet. Should the investigation conclude that the deposit can be mined profitably, then AMAX would provide the necessary funds for its development.

Kerr Addison Mines Ltd. made a similar study of the deposit in 1970 and dropped its option in 1971. The company spent nearly $3 million on underground exploration, diamond drilling, and other related work. The study resulted in increasing ore reserves from 70 million tons grading 0.141% molybdenite at a stripping ratio of 1.3 to 1, to ore reserves of over 104 million tons grading 0.16% molybdenite and a stripping ratio in the order of 0.63 to 1. The improvement in demand for molybdenum accounted for the renewed interest in the deposit.

AMAX purchased the assets and property of British Columbia Molybdenum Ltd., owned by Kennecott Copper Corp., at Kitsault, British Columbia. The mine and mill, having a capacity of 6,000 tons of ore per day, commenced operation early in 1968 and was closed on April 28, 1972, because of weak molybdenum prices and high operating cost. Approximately 22 million pounds of molybdenum were produced during the period. Ore reserves were reported at 40 million tons grading 0.23% molybdenite.

Greenland.—Arktish Minekompagni A/S, a joint venture of Nordisk Mineselskab A/S and AMAX, conducted exploration on a large molybdenite deposit north of Scoresbysund, eastern Greenland. The deposit (Malmberg) contains an estimated 120 million tons of ore grading 0.25% molybdenite and another 100 million tons of ore grading 0.20% molybdenite.

Iran.—The Sar-Cheshmeh Copper Mining Co. continued development of a vast copper-molybdenum deposit near Kerman, south-central Iran. Ralph M. Parsons Co. was awarded a $400 million contract to provide project management, engineering design and related work, and construction and associated services for the mine site, crushing plant, concentrator, and smelter. The facility was expected to process approximately 42,000 tons of ore per day to produce 145,000 tons of blister copper annually and an undisclosed amount of molybdenum. Operations were scheduled to reach full production during 1977.

Mexico.—Asarco Mexicana S.A. and Cía. Mexicana de Cobre S.A. continued engineering studies in preparation for development of the La Caridad copper-molybdenum deposit in the Province of Sonora, Mexico. An open pit mine, mill, smelter, and refinery (costing $300 million) with a throughput of 250,000 tons of metal annually was contemplated. Some 40 million tons of overburden will be removed to reach the ore deposit. Ore reserves were estimated at 700 million tons having an average grade of 0.76% copper and 0.016% molybdenite. Parson-Jurden Corp., a Division of Ralph M. Parsons Co., was the contractor on the project. At yearend, company officials reported obtaining $150 million to initiate construction of the facility.

Tormex Mining Developers Inc. and Industrias Peñoles S.A. negotiated a conditional purchase contract for the Santo Tomás mineral property near Choix from a group of Mexican and American vendors. Santo Tomás consists of 23,000 acres of land and a porphyry copper deposit containing molybdenum and other minerals. The ore deposit, amendable to open pit mining, was discovered in 1970. Some 40 diamond drill holes were completed which outlined 200 million tons of ore averaging about 0.4% copper and an undisclosed amount of molybdenum, gold, and silver. The ore deposit is about 5,000 feet long and 1,000 feet wide. It is adjacent to the Reforma silver-lead-zinc mine which produces ore at a rate of 500 tons per day.

Mongolia.—Development was underway of the vast Erdentyin-Owo copper-molybdenum deposit located 150 miles northwest of Ulan Bator, Mongolia. To date, an electric powerline (connected to the Soviet grid system) and a 105 mile railroad to the Trans-Mongolian line were completed. An open pit mine, concentrator, and townsite were in various stages of construction. The project was receiving financial assistance from U.S.S.R. and the mine-mill facility was expected to provide copper and molybdenum concentrate for export markets.

Norway.—A/S Knaben Molybdaengruber suspended operations at the underground Knaben mine Kvinesdal, Norway, because of rising production costs, weakness in the demand for molybdenum and subsequent low prices, and increasing inventories. The Knaben mine, Europe's only molybdenum producer, has been in operation since 1885, except for the years 1919 and 1923, and a short period during World War II. Production was rather stable during recent years and for 1971 (latest figures available) amounted to 344,252 short tons of ore from which 646,270 pounds of molybdenum were recovered.

Panama.—Cobre Panama S.A., a subsidiary formed by a Japanese consortium composed of Mitsui Mining & Smelting Co. Ltd., Dowa Mining Co. Ltd., Mitsubishi Metal Corp., and Nittetsu Mining Co. Ltd., signed a 4-year exploration contract with the Government of Panama. The company will make a feasibility study and conduct exploration work for copper, molybdenum, tin, lead, and zinc over an area totaling nearly 100,000 acres near Petaquilla in the Donoso District of Colón. A vast copper-molybdenum deposit was discovered in the area by a United Nation's financed exploration project for underdeveloped countries in 1968. Some 5,000 feet of diamond drilling was completed during the initial study which outlined a mineralized belt containing an estimated 300 million tons of copper-molybdenum ore. Cobre Panama S.A. will spend about $1.5 million for additional diamond drilling over a period of 2 years. The company negotiated an option to develop the mineral deposit in the area at the conclusion of its investigation.

Peru.—Cía. Minera Cerros Negros, a subsidiary of Homestake Mining Co. (U.S.A.) and Mitsubishi Mining Co. Ltd. (Japan), agreed to conduct additional exploration work and make a feasibility study of the Pashpap copper-molybdenum deposit situated in the Province of Huaylas. Ore reserves were estimated at 53 million tons having an average grade of 0.86% copper and 0.03% molybdenite. Should the study conclude that the deposit is economically minable, the company would invest $22 million for development of a mine and concentrator having a capacity to process 6,000 tons of ore per day. Approximately 48,000 tons of copper concentrate and 1.7 million pounds of molybdenum would be produced annually.

A consortium which included Empresa Minera del Perú (Minero Perú) and five Japanese companies agreed to conduct a $2 million feasibility investigation of the Michiquillay copper-molybdenum deposit east of the city of Cajamarca, northern Peru. In recent years, Asarco spent several million dollars on diamond drilling of the deposit and on construction of access roads. A principal feature of the study will be to estimate construction and operating costs of slurry pipelining the concentrate from the mill to the coast, a distance of 184 miles. The ore reserves at Michiquillay were estimated at 628 million tons having an average grade of 0.72% copper and an undisclosed amount of molybdenum. It was reported that an estimated $457 million would be required to develop the deposit. Minero Perú engineers anticipate construction of a mine-mill facility with a capacity to process about 40,000 tons of ore per day.

Southern Peru Copper Corp. (SPCC) obtained financing of $200 million from a number of United States, Canadian, European, and Japanese banks to continue development of the Cuajone copper-molybdenum deposit located some 550 miles southeast of Lima. The property has been under development since 1969 when it was estimated that about $500 million would be required to complete the project. Work underway during 1973 included overburden stripping and construction of a railroad tunnel. Some 200 million tons of overburden must be removed to expose the ore body. To date, SPCC expenditures amounted to over $160 million and they expect to spend an additional $152.4 million of company funds to complete the project. Company officials were negotiating long-term sales contracts for the planned output of 180,000 tons of blister copper annually to assure completion of the project in 1976. Work projects scheduled for 1974 included construction of a concentrator, expansion of the Ilo smelter, and building new townsite and ancillary facilities.

Sweden.—Molyscand AB, a joint venture of Kema Nord AB, A. Johnson & Co. and Höganäs AB, conducted research and development on a process for the production of molybdic oxide by a chemical extraction method. The process would eliminate pollution problems associated with traditional methods of oxide production. A pilot plant was expected to commence operation early in 1974.

TECHNOLOGY

The effects of varying amounts of molybdenum, carbon, chromium, and cobalt on yield strength, toughness, and tempering behavior of martensitic steels were described.[4] Maximum toughness at a given yield strength was obtained when steel was tempered until the carbides were completely dissolved. Molybdenum was primarily responsible for secondary hardening. Dispersion of the carbides accounted for the excellent combination of strength and toughness exhibited by these steels.

Tensile strength tests were conducted on oxidized and unoxidized polycrystalline molybdenum specimens and results described.[5] A surface oxidation treatment by heating at 500° C resulted in producing a thin oxide film on the specimens. Tensile tests performed on both of these polycrystalline molybdenum specimens proved that the oxide film had no effect on the ductile-brittle transition temperature. Embrittlement by surface oxidation is characteristic of group V elements of the periodic table, but not of those in group VI in which oxygen is almost completely insoluble.

A process for extracting molybdenum metal from calcium molybdate by aluminothermic reduction was investigated.[6] Calcium molybdate was reduced with aluminum in a refractory-lined open-top vessel to produce aluminothermic molybdenum. The material was then processed by electron-beam melting and by molten salt electrorefining to remove the aluminum. The final molybdenum metal compared favorable with that produced by other processes.

Pitting, stress corrosion, and general corrosion in ferritic stainless steels and other alloys were investigated.[7] Defects in metals have been a continuing problem in many industrial and chemical plants, especially those utilizing a corrosive process. A new ferritic stainless steel was developed which overcomes the disadvantage of many austenitic and ferritic stainless steels. The material has the traditional immunity of ferritic stainless steel to stress-corrosion

[4] Speich, G. R., D. S. Dabkowski, and L. F. Porter. Strength and Toughness of Nickel-Iron Alloys Containing Carbon, Chromium, Molybdenum, and Cobalt. Met. Trans., v. 4, No. 1, January 1973, pp. 305–315.

[5] Schlosser, S., A. A. Johnson, and K. Mukherjee. The Low Temperature Tensile Properties of Surface Oxidized Poly-crystalline Molybdenum. Mater. Sci. & Eng., v. 11, No. 2, February 1973, pp. 81–86.

[6] Mehra, O. K., D. K. Bose, and C. K. Gupta. Molybdenum Metal by the Aluminothermic Reduction of Calcium Molybdate. Met. Trans., v. 4, No. 3, March 1973, pp. 691–694.

[7] Steigerwald, Robert F. New Ferritic Stainless Steel to Resist Chlorides and Stress-Corrosion Cracking. Tech. Assoc. of the Pulp and Paper Ind., v. 56, No. 4, April 1973, pp. 129–133.

resistance and fabricability. The latter physical property was obtained by the addition of chromium and molybdenum.

The production of molybdenum carbide by electrolysis of sodium molybdate was described.[8] Sodium molybdate was dissolved in a fused bath of sodium carbonate, sodium tetraborate, sodium fluoride, and potassium fluoride and the carbide produced by molten salt electrolysis. Under optimum conditions of bath composition, bath temperature, and cathode current density, a maximum electrodeposition rate of the carbide was obtained. The carbide was then admixed with a controlled amount of molybdenum dioxide for vacuum thermal sintering treatment to yield molybdenum metal of purity comparable to conventional extraction processes.

An inert gas fusion method to determine oxygen in molybdenum metal using a limited platinum bath was described.[9] In addition to its economical advantage, the method had higher sensitivity, and greater precision and accuracy. Since molybdenum often contains oxygen concentrations of only a few ppm, a high bath-to-metal ratio had an adverse influence on sensitivity and precision. The reduction in cost of the analysis was due to smaller amounts of the noble metal required for the method.

The sintering properties and chemical stability of molybdenum in the presence of an organic binder and a reducing atmosphere was investigated.[10] Molybdenum powders sintered under constant rates of heating resulted in an effective activation energy of 37 kilocalories per mole. A thermochemical diagram showed the carbonization or oxidation of molybdenum during the sintering process under various dew points. By proper control of the atmosphere and particle size, shrinkage limited to 20% was achieved in molybdenum powder sintered to 1,550° C. Nitridization did not occur in the forming gas atmosphere in the presence of carbon.

Elevated temperature strength of chromium-molybdenum steel with varying carbon contents was investigated because of its potential use in liquid-metal fast breeder reactors.[11] Reducing carbon content had little influence on elevated-temperature tensile strength of annealed steel. Creep-rupture strength of the annealed material decreased as the carbon content was lowered. The combined effects of carbide coarsening and decarburization during exposure of fine-grained commercial steel to liquid sodium caused substantial reductions in elevated temperature tensile strength and moderate reductions in rupture strength. Lubricating properties of solid lubricant was described.[12]

Molybdenum disulfide and graphite are the most commonly used lubricants. Their outstanding lubricating properties are obtained from the layered crystal structure of the minerals. In general, molybdenum lubricants have the advantage of good stability at high temperatures and in a chemically reactive environment. They also have design advantageous of lighter weight, improved dynamic and mechanical stability, and more simplified design than conventional oil and grease lubricants.

Gamma coarsening and elevated-temperature hardness was investigated as a function of molybdenum content, time, and temperature in superalloys and results published.[13] The alloys were selected from specimens containing 1, 3, 4½, and 6 weight-percent aluminum, 3½ weight-percent titanium, and 0, 2, 5, and 8 weight-percent molybdenum. The alloy specimens were solution-treated, thence aged to 112 hours at 1,700° F and to 1,000 hours at 1,400° F. Molybdenum retarded the coarsening of gamma on aging; this retarding effect was most pronounced in alloys containing 6 weight-percent aluminum. Hardness testing in a vacuum at temperatures to 1,750° F showed that molybdenum also

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[8] Suri, A. K., T. K. Mukherjee, and C. K. Gupta. Molybdenum Carbide by Electrolysis of Sodium Molybdate. J. Electrochem. Soc., v. 120, No. 5, May 1973, pp. 622–624.

[9] Pauwels, J. A., A. Kahles, and G. Kraft. The Determination of Oxygen in Molybdenum by the Inert Gas Fusion Method Using a Limited Platinum Bath. J. Less-Common Met., v. 30, No. 1, January 1973, pp. 173–176.

[10] Young, Wayne S. Molybdenum Sintering and the Molybdenum-Oxygen-Carbon System. J. Less-Common Met., v. 32, No. 3, September 1973, pp. 321–331.

[11] Sponseller, D. L., M. Semchyshen, and P. J. Grobner. Effects of Low-Carbon Content and Exposure to Liquid Sodium on Elevated Temperature Behavior of Chromium-Molybdenum Steel. Pres. at Mater. Eng. Congress Symp., Cleveland, Ohio, Oct. 19–22, 1970; ASM paper in Proc., American Metal Climax, Inc., May 1973, pp. 73–112.

[12] Campbell, Mahlon E. Solid Lubricants—Where They Stand Today. Chem. Eng., v. 80, No. 10, October 1973, pp. 56–66.

[13] Bliss, V., and D. L. Sponseller. The Effect of Molybdenum on Gamma Coarsening and on Elevated-Temperature Hardness in Some Experimental Nickel-Base Alloys. Met. Trans., v. 4, No. 8, August 1973, pp. 97–104.

increased the elevated temperature hardness.

The effect of corrosion on iron-chromium alloys containing 2, 4, 6, and 8% molybdenum in a solution of sulfuric acid at a temperature of 77° F were described.[14] The effect of molybdenum on potential current density curves was determined potentiostatically. Increasing molybdenum content caused the critical current density to decrease and the open circuit potential to become increasingly noble. Alloys with 8% molybdenum did not show any anodic dissolution and passivated spontaneously. Some theoretical considerations of the passivation mechanism were discussed in connection with additional electrochemical measurements.

Patents were granted for upgrading low-grade molybdenum flotation products from a bulk copper-sulfide molybdenum-sulfide primary concentrate; [15] purification of rhenium containing solutions obtained in the processing of molybdenite; [16] extraction of molybdenum and rhenium from molybdenite without atmospheric pollution;[17] sulfuric acid leaching of sulfide ores of molybdenum; [18] extraction of molybdenum and rhenium values from molybdenite concentrate;[19] extraction of molybdenum and rhenium from oxidation leaching solutions with nitric acid; [20] pollution-free recovery method for rhenium from molybdenum; [21] roasting molybdenite to produce oxide; [22] extraction of molybdenum from aqueous solutions obtained by leaching alkali-fused molybdenum; [23] recovery of molybdenite and rhenium from molybdenite.[24]

[14] Rockel, M. B. The Effect of Molybdenum on the Corrosion Behavior of Iron-Chromium Alloys. Corrosion, v. 29, No. 10, October 1973, pp. 393–396.

[15] Bloom, P. A., S. J. Hussey, and L. Evans (assigned to U.S. Secretary of the Interior). Upgrading of Low-Grade Molybdenite Flotation Products. U.S. Pat. 3,714,325, Jan. 30, 1973.

[16] Ziegler, M. (assigned to W. C. Heraeus G.m.b.H.). Ion Exchange. U.S. Pat. 3,733,388, May 15, 1973.

[17] Martin, B. E., and M. B. MacInnes (assigned to GTE Sylvania Inc.). Extraction of Molybdenum and Rhenium From Molybdenite Without Atmospheric Pollution. U.S. Pat. 3,725,524, Apr. 3, 1973.

[18] Fuchs, W. (assigned to Treadwell Corp.). Sulfuric Acid Leaching of Sulfide Ores of Molybdenum. U.S. Pat. 3,726,667 Apr. 10, 1973.

[19] Daugherty, E. W., A. F. Erhard, and J. L. Drobnick (assigned to Molybdenum Corp. of America). Extraction of Molybdenum and Rhenium From Molybdenite. U.S. Pat. 3,739,057, June 12, 1973.

[20] Peterson, H. D. (assigned to Molybdenum Corp. of America). Extraction of Molybdenum and Rhenium From Oxidation Leaching of Molybdenite. U.S. Pat. 3,751,555, Aug. 7, 1973.

[21] Kruesi, P. R. Electrowinning, Pollution-Free Recovery Method of Rhenium From Molybdenite. U.S. Pat. 3,755,104, Aug. 28, 1973.

[22] Arrizaga, C., and A. Gajardo. Roasting Molybdenite to Produce Molybdenum Oxide. U.S. Pat. 3,761,565, Sept. 25, 1973.

[23] Kim, T. K., L. R. Pagnozzi, M. E. MacInnes, and J. M. Laferty (assigned to GTE Sylvania Inc.). Extraction of Molybdenum From Aqueous Solutions Obtained by Leaching Alkali-Fused Molybdenite. U.S. Pat. 3,770,869, Nov. 6, 1973.

[24] Lake, J. L., J. E. Litz, R. B. Coleman, M. Goldenberg, and M. Vojkovic (assigned to Continental Ore Corp.). Recovery of Molybdenum and Rhenium From Molybdenite. U.S. Pat. 3,770,414, Nov. 6, 1973.

Natural Gas

By William B. Harper,[1] Robert J. Jaske,[2] and Leonard L. Fanelli [3]

Natural gas consumption of nearly 23 trillion cubic feet (Tcf) in 1973 was slightly below that of 1972. The largest decrease in consumption was a 373-billion-cubic-feet (Bcf) reduction by electric utility companies. This was due to curtailment of both interruptible and firm deliveries by pipeline companies. These curtailments were most significant during the summer months when peak power demand occurs. The next largest reduction was in residential usage amounting to 247 Bcf. This was attributed to warmer than normal weather during the 1973 heating season months. These decreases were almost offset by increased demand by industrial users whose consumption increased 7% or almost 0.6 Tcf. Marketed production totaled 22.65 Tcf in 1973, a volume nearly 0.116 Tcf, or 0.5% higher than that of 1972.

Approximately 29 Bcf of natural gas was exported by pipeline, of which 51.4% was moved to Canada. Mexico received the remaining 14 Bcf of natural gas exported by pipeline. In addition, 48.3 Bcf of LNG was exported to Japan from Alaska during 1973.

Net pipeline imports exceeded 1 Tcf in 1973 for the second consecutive year. Canada accounted for all but 0.1% of pipeline imports in 1973. Imports from Mexico dropped 80%, from 8.1 Bcf in 1972 to 1.6 Bcf in 1973. In addition, 1,167,000 barrels of liquefied natural gas (LNG), equivalent to just over 4 Bcf, were imported from Algeria and Canada.

Proved reserves of natural gas declined again as withdrawals (production) exceeded, by a wide margin, additions to reserves from new discoveries and extensions of known fields. Also, previous estimates of reserves were revised downward, particularly in Texas. The decrease for Texas was 4.7 Tcf in 1973 following a 1.5 Tcf decrease in 1972.

The average value of natural gas at the wellhead moved upward 3.0 cents from 18.6 cents to 21.6 cents per thousand cubic feet (Mcf).

[1] Mineral specialist, Division of Fossil Fuels—Mineral Supply.
[2] Petroleum engineer, Division of Fossil Fuels—Mineral Supply.
[3] Survey statistician, Division of Fossil Fuels—Mineral Supply.

Table 1.—Salient statistics of natural gas in the United States

	1969	1970	1971	1972	1973
Supply:					
Marketed production [1] million cubic feet	20,698,240	21,920,642	22,493,012	22,531,698	22,647,549
Withdrawn from storage do	1,379,488	1,458,607	1,507,630	1,757,218	1,532,820
Imports do	726,951	820,780	934,548	1,019,496	1,032,901
Total do	22,804,679	24,200,029	24,935,190	25,308,412	25,213,270
Disposition:					
Consumption do	20,922,800	22,045,799	22,676,581	23,009,445	22,965,914
Exports do	51,304	69,813	80,212	78,013	77,169
Stored do	1,498,988	1,856,767	1,839,398	1,892,952	1,974,324
Lost in transmission, etc do	331,587	227,650	338,999	328,002	195,863
Total do	22,804,679	24,200,029	24,935,190	25,308,412	25,213,270
Value at wellhead:					
Total thousand dollars	3,455,615	3,745,680	4,085,482	r 4,180,462	4,894,072
Average cents per thousand cubic feet	16.7	17.1	18.2	18.6	21.6

r Revised.
[1] Marketed production of natural gas represents gross withdrawals less gas used for repressuring and quantities vented and flared.

Pipeline networks were expanded again in 1973. Specific figures on line additions are not available. Construction of new synthetic gas (SNG) plants using liquid hydrocarbons, such as naphtha and natural gas liquids, for feedstocks advanced in 1973. There were 3 SNG plants operating, 4 in the startup and testing stage, and 14 under construction.

Coal gasification received additional impetus as the result of an agreement between the U.S. Department of the Interior and the American Gas Association (AGA) to jointly finance a pilot plant program that will cost about $120 million over a 4-year period. This project is being funded through the Department of the Interior's Office of Coal Research. Pilot plants include the Institute of Gas Technology's HYGAS process at Chicago, Ill., and the Consolidation Coal Co.'s CO_2-Acceptor process at Rapid City, S. Dak. A third plant, Bituminous Coal Research's BI-GAS process, is being constructed at Homer City, Pa., and should be finished during 1974.

The Bureau of Mines is developing a synthane process with emphasis on producing more methane directly in the gasifier, thus reducing the load in the methanation step. A pilot plant at Bruceton, Pa., is scheduled to be completed in 1974.

Lack of additional gas supplies has created problems for both transmission companies and distributors. Firm volume curtailments for the period April 1973-March 1974, reported by 42 pipeline transmission companies, totaled 1.19 Tcf according to the Federal Power Commission.

Legislation and Government Programs.—Federal Power Commission (FPC) Area Rate Proceedings:

South Louisiana Area.—Subsequent to affirmation by the Fifth Circuit Court of FPC Opinion 598, the Supreme Court was petitioned by the New York Public Service Commission and others to review the Fifth Circuit Court's decision. By way of background, FPC Opinion 598 accepted the United Distribution Companies Settlement Proposal in the Area Rate Proceeding (AR 61-2 et al, AR 69-1). The Settlement Proposal provided for a new gas price of 26.0 cents per Mcf on contracts dated since October 1, 1968; flowing gas prices were 22.375 cents onshore and 21.375 cents offshore on contracts dated prior to October 1, 1968. Also in the proposal were provisions for contingent price escalations of 0.5 cents, 1.0 cents, and 1.5 cents per Mcf upon a total commitment of 7.5 Tcf, 11.25 Tcf, and 15.0 Tcf, respectively, of new gas reserves to interstate pipelines in South Louisiana prior to October 1, 1977. The Settlement Proposal included a moratorium on further rate increases until October 1, 1977 for new gas and until October 1, 1976 for flowing gas. Also involved were refunds of approximately $150 million, but with provision for work-off at a rate of 1 cent per Mcf upon commitment of new gas reserves to interstate pipelines in South Louisiana over a 5-year period.

Other Southwest Area.—FPC Opinion 607 determined rates in the area ranging from 19.4 cents to 20.6 cents per Mcf for gas produced under contracts dated before October 1, 1968. The area includes Mississippi, Arkansas, 4 counties in northwest Alabama, northern Louisiana, Texas Railroad Commission Districts 5, 6, and 9, and 56 counties in eastern and southeastern Oklahoma.

For production under contracts dated after October 1, 1968, rates ranged from 22.5 cents to 26.0 cents. In January 1972, the FPC issued an opinion on rehearing (No. 607-A) that included a proviso giving natural gas producers the option of meeting their refund responsibilities by the dedication of new reserves to interstate commerce. This opinion was sent on appeal to the U.S. Court of the Fifth Circuit, and the Court upheld the FPC decision in Opinion 607, establishing rates for pre-1961 contracts, 1961–68 contracts, and post-October 1, 1968, "new" gas contracts.

A petition was filed on September 6, 1973, by the Mobil Oil Corp. for a writ of certiorari to review the Fifth Circuit decision. Subsequently, the Supreme Court affirmed the Fifth Circuit decision upholding the FPC decision in Opinion 607.

Appalachian and Illinois Basin Areas.—Four natural gas companies filed a petition in January 1972, asking that ceiling rates for gas purchases from the Appalachian Basin be increased to at least 50 cents per Mcf. Because the four companies faced a severe shortage of natural gas, they requested the increase. The FPC, in Opinion 639, denied the request to increase the price of gas in the Appalachian Area to 50 cents for Mcf on contracts dated after February 1, 1972, in order to not perpetuate and extend the contract vintage system of producer pricing.

Pipeline Safety.—Based on failure reports from which table 2 was developed, the Office of Pipeline Safety (OPS) estimated that 67.4% of the gas distribution incidents and 57.7% of the transmission line failures during 1973 resulted from outside force damage. In 1973, an amendment to the Federal Gas Pipeline Safety Standards revised the term "service line" and resulted in the regulation of certain service lines in distribution systems not previously regulated by the U.S. Department of Transportation. Another amendment was the extension in 49 CFR Part 190 on odorization of gas. This allowed for time to complete a separate rule-making proceeding on transmission line odorizing, initiated by notice of proposed rule making on August 15, 1973. Another amendment in 1973 concerned flexibility in qualifying pipe for use in gas pipelines.

DOMESTIC PRODUCTION

Gross production of natural gas represents the total amount produced, including marketed production of gas, gas returned to the formation for pressure maintenance, and the gas vented or flared. In 1973, gross production aggregated nearly 24.1 Tcf, slightly above the 24.0 Tcf produced in 1972. However, marketed production increased 115.8 Bcf, or approximately 0.5%, during 1973 as the quantity of gas used for repressuring declined.

There was a 1.7% increase in the gross production from gas wells, from 19.04 Tcf in 1972 to 19.37 Tcf in 1973. This more than offset a reduction of 0.278 Tcf in gas produced from oil wells. Increased gross production occurred in Louisiana, New Mexico, Colorado, Michigan, Montana, Ohio, Utah, Pennsylvania, and Virginia. Significant gains also occurred in some of the smaller gas producing States which includes Alabama and Florida. Availability and the startup of new natural gas processing plants in Alabama and Florida in which sulfur recovery units are incorporated were the prime causes for these production increases. Much of the natural gas in this region has a high sulfur content. Higher prices for gas, however, provided an incentive to extract the sulfur so that the gas would be acceptable for pipeline transmission. The sulfur extracted from the gas is sold to fertilizer manufacturers.

On the negative side, there was a sizable reduction in gross withdrawals of gas in Texas. However, this was more than offset by the gain in gross withdrawals in Louisiana. A decrease in withdrawals from both gas wells and oil wells resulted in a drop in Texas gas production of 0.26 Tcf in 1973. There was, however, a reduction in gas used for repressuring and gas vented and flared so that the drop in marketed production was narrowed to 0.144 Tcf or a 1.6% net decrease. Marketed production in Louisiana was 3.4% higher in 1973 largely because of a 6% increase in withdrawals from gas wells.

In California, marketed production of gas declined 7.8% in 1973 following a 20.5% drop that occurred in 1972. In the last 2 years the total drop in marketed California production amounts to 163.3 Bcf. Similar to that in 1972, the decrease during 1973 was primarily in gas withdrawals from oil wells. This was coupled with some decrease in withdrawals from gas wells. The 1973 volume changes from 1972 were a decrease of 12.1 Bcf for gas wells and a decrease of 29.7 Bcf for oil wells. The latter shows a leveling off from the 134.6 Bcf drop in gas withdrawals from oil wells experienced in 1972. However, the decreased withdrawals from gas wells reversed a 1972 gain of 10.8 Bcf. The established trend over the last 6 years has been a steady drop in gross withdrawals from both oil and gas wells. The average decrease was 58 Bcf per year for the last 6 years. An unusually large drop of 123.8 Bcf was reported in 1972 and is included in the 6-year average. There are no indications of a reversal of the declining trend. Some lessening in the drop in California could come about if the Kettleman Hills field were utilized to a greater degree. Kettleman now is basically a gasfield with relatively high reservoir pressures and only minimal oil production.

Rising prices for natural gas and the endorsement by the Courts, of FPC Area Rate Proceedings Opinions, encouraged gas exploration and production. During 1973, there were 7,169 gas wells drilled and completed compared with 4,928 gas wells in 1972 or a gain of 45.4% as shown in table

4. There were 900 exploratory gas well completions in 1973 as compared with 601 similar wells in 1972, a gain of 49.8%.

Likewise, higher prices for natural gas have made it economical to build natural gas processing plants with sulfur recovery units. As a result, efforts are being made to drill and explore for gas whether it be sweet or sour. This effort was noticeable in States where production has been small, such as in Alabama. Production in that State in 1973 approximately tripled; proved reserves increased from 245.7 Bcf as of December 31, 1972, to 327.4 Bcf as of December 31, 1973, an increase of 33.2%.

Gas wells also include condensate wells producing from high-pressure natural gas reservoirs. Some of these reservoirs produce considerable quantities of liquid hydrocarbons such as pentanes and heavier, described generically as "condensate."

Significant increases in gas well completions in 1973 were widespread. Reduced activity occurred in only six States: Illinois, Kentucky, Louisiana, Montana, Nebraska, and Virginia.

It is interesting to note, however, that the accelerated pace of gas well drilling activity is taking place primarily onshore. Offshore gas well exploratory drilling in 1973 was far below that of 1972. However, offshore development well drilling increased sharply in Louisiana in 1973.

There has been a steady increase in the number of gas and condensate wells producing. In 1968, for example, there were 114,391 producing wells, and by the end of 1973, there were 124,168 wells producing. Most of this increase has occurred after 1970.

CONSUMPTION AND USES

Consumption of natural gas in 1973 totaled 22.966 Tcf a slight decrease from 1972. Gas delivered to consumers aggregated 19.825 Tcf, a small decline from the comparable total of 19.880 Tcf in 1972.

Residential use in 1973 decreased by 4.8% to 4.879 Tcf. The decrease was due to warmer than normal temperatures in the heating season months. The decrease in use was accompanied by a 1.9% increase in number of residential users.

Over the decade 1963–73, the number of househeating customers grew from 33.45 million to 40.65 million or at an annual growth rate of 2.15%. Between 1972 and 1973 growth contracted to 1.9%. Trends in the number of househeating accounts by Census Regions for the years 1963, 1972, and 1973 are shown in the following tabulation:

Census regions	Gas househeating customers (thousands)		
	1963	1972 r	1973
New England	1,476	1,616	1,603
Middle Atlantic	7,272	7,699	7,713
East North Central	7,487	9,152	9,386
West North Central	2,692	3,309	3,399
South Atlantic	2,723	3,387	3,513
East South Central	1,628	1,848	1,959
West South Central	3,877	4,599	4,575
Mountain	1,357	1,939	2,021
Pacific	4,939	6,322	6,476
Total	33,451	39,871	40,645

r Revised.

By far the largest segment in the consumer-use category is the industrial group. About 44.1% of the gas delivered to consumers is used by industry. Industrial uses in 1973 accounted for 8.74 Tcf, a 7% increase over that of 1972. Most of the gas used by industry is consumed as fuel, and more than 1.07 Tcf was used as refinery fuel as indicated in the footnote in table 8. Natural gas is also an important petrochemical feedstock. Most of the ammonia produced in the United States is obtained by reforming natural gas to produce the hydrogen-nitrogen mix required for ammonia synthesis. It is calculated that, on the average, natural gas consumed per ton of ammonia amounts to about 37 Mcf. This would mean that more than 0.57 Tcf of natural gas was used to produce the 15.4 million tons of synthetic ammonia made in 1973. Methanol production is another important petrochemical industry consumer of natural gas. There were nearly 7.2 million short tons of methanol produced in 1973. Using 36 Mcf per short ton as a yardstick, it is calculated that 0.26 Tcf of natural gas was consumed in methanol production. Data necessary for the calculation of other petrochemical feedstock consumption are not available.

The downtrend in natural gas consumption by electric utilities that started in 1972 continued in 1973 when use de-

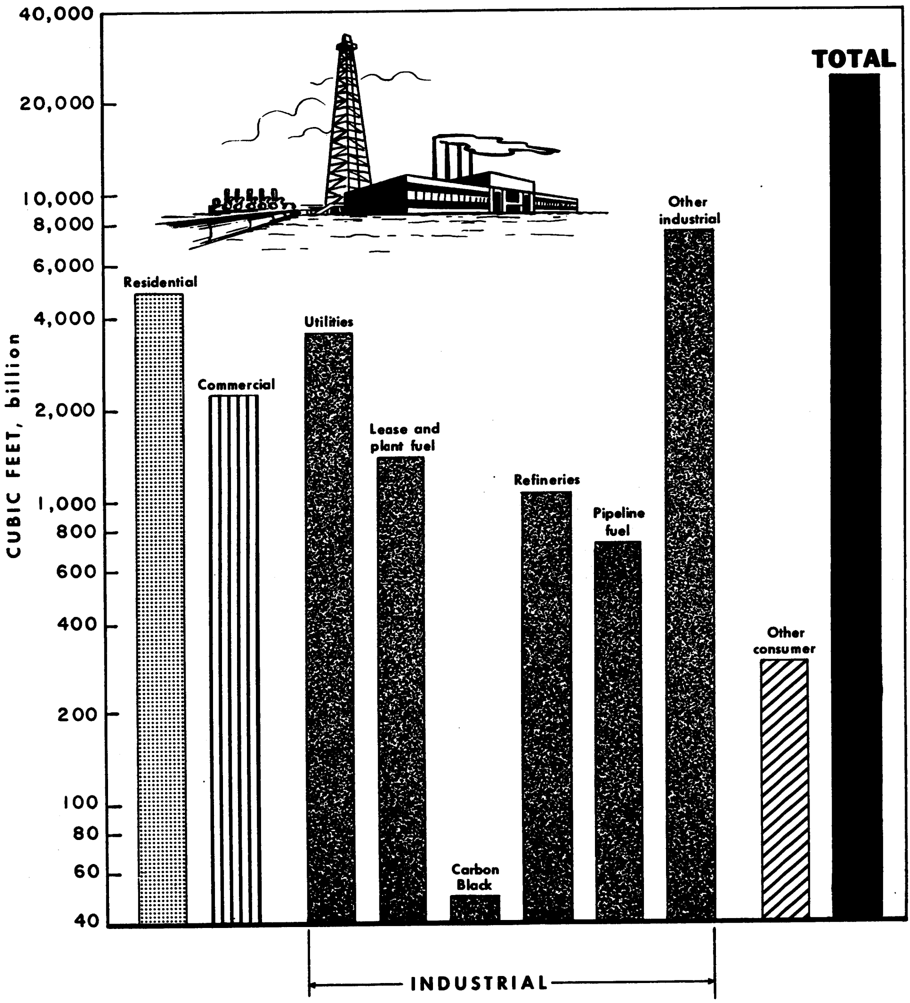

Figure 1.—Disposition of natural gas consumed in the United States by principal use.

clined slightly, to 3.60 Tcf from 3.98 Tcf. All areas showed a decrease except West North Central, which increased consumption slightly.

There was a slight decrease in the number of commercial consumers in 1973 from 3,357,000 to 3,335,000. Use of gas in this category, however, increased very slightly to 2.288 Tcf from 2.286 Tcf.

In addition to gas delivered to consumers, there are three categories of gas-use separately classified; namely, lease and plant fuel, pipeline fuel, and extraction losses. The loss in gas processing plants (shrinkage) increased 0.9% in 1973. In 1973, these plants processed 19.68 Tcf of natural gas (86.9% of marketed production), a decrease of 1.1% from the 19.91 Tcf processed in 1972.

Although there has been a marked growth in natural gas use ever since long-distance natural gas transmission lines became a reality, the tight supply situation is becoming more and more critical for pipeline transmission companies. In fact, the shortage of gas forced major interstate gas pipeline companies to curtail service. During the April 1973-March 1974 season, 17 of the 42 major pipelines listed in table 10, reported firm total volume curtailments aggregating almost 1.57 Tcf or 8.3% of their firm requirements of nearly 18.8 Tcf of natural gas. Table 10 is based on data submitted to the FPC. A breakdown of actual interruptible sales and curtailments for the period April 1973 through March 1974 is shown in table 11.

The uncertainties as to the availability of new gas supplies is also having an impact on expansion of pipeline networks. Data showing the growth of the pipeline networks is shown in the following tabulation:

Mileage, natural gas pipelines

	1961	1971	1972	1973
Field and gathering	56.7	66.5	67.1	NA
Transmission	191.9	256.9	260.2	NA
Distribution	410.4	611.3	623.9	NA
Total	659.0	934.7	951.2	NA

NA Not available.

RESERVES

Production of natural gas has exceeded discoveries of new gas during 5 of the last 6 years, and 1973 proved to be no exception. During 1973, production exceeded discoveries by a wide margin, and proved reserves of natural gas dropped from 266.1 Tcf at yearend 1972 to 250.0 Tcf at yearend 1973, or a decline of 6.1%, according to the Natural Gas Reserves Committee of AGA.

Net additions to reserves reported for the United States in 1973 aggregated nearly 6.5 Tcf. The largest segment, some 6.2 Tcf, was derived from extensions to known fields. More than one-half of the 2.0 Tcf total for new reservoir discoveries in oilfields came from Louisiana. In addition, discoveries of new fields totaled almost 2.15 Tcf of reserves. On the negative side, however, previous estimates or reserves in some States were revised. On balance, there was a revision reduction for the United States, as a whole, of nearly 3.5 Tcf.

There were some increases in the reserves of natural gas in 13 States. However, significant increases occurred in only seven States. Michigan had the largest increase, 0.25 Tcf. Next in order were Colorado, Alaska, New Mexico, Pennsylvania, Alabama, and Mississippi. These increases aggregated about 1 Tcf. On the negative side, reserves in major gas-producing States declined sharply. Texas gas reserves dropped from 95.0 Tcf to 84.9 Tcf, a decline of more than 10 Tcf. Likewise, in Louisiana, proved reserves decreased 5.8 Tcf or 7.8% to 69.15 Tcf.

Natural gas reserves committed to interstate pipelines declined in 1973 for the sixth consecutive year. Committed dedicated domestic reserves fell by 12.4 Tcf in 1973, declining from 146.9 Tcf to 134.4 Tcf. Gas produced and purchased by pipelines amounted to 13.7 Tcf, which is 3.6% down from the 14.2 Tcf reported in both 1971 and 1972. The reserve-production ratio for interstate reserves dropped from 10.3 at the end of 1972 to 9.8 by the yearend 1973. These data are shown in the following tabulations:

1973 Yearend domestic reserves, production, and purchases of interstate natural gas pipeline companies

(Billion cubic feet at 14.73 psia at 60° F)

	Major supply companies	Minor supply companies	Total
Number of companies	25	38	63
Gas reserves at yearend:			
Company owned	12,453	721	13,174
Independent producer contracts	119,568	1,704	121,272
Total	132,021	2,425	134,446
Percent of total	98.2	1.8	100.0
Annual production and purchases:			
Company owned	766	64	830
Independent producer contracts	12,652	213	12,865
Total	13,418	277	13,695
Percent of total	98.0	2.0	100.0

Preliminary summary of domestic natural gas reserves of interstate natural gas pipeline companies

(Billion cubic feet at 14.73 psia at 60° F)

1. Total dedicated gas reserves as of Dec. 31, 1972	146,894
2. Revisions and additions during 1973 (item 1 minus item 3)	1,247
3. Gas reserves as of Dec. 31, 1972 and changes during 1973 (item 4 plus item 5)	148,141
4. Gas produced during 1972	13,695
5. Total dedicated gas reserves as of Dec. 31, 1973	134,446

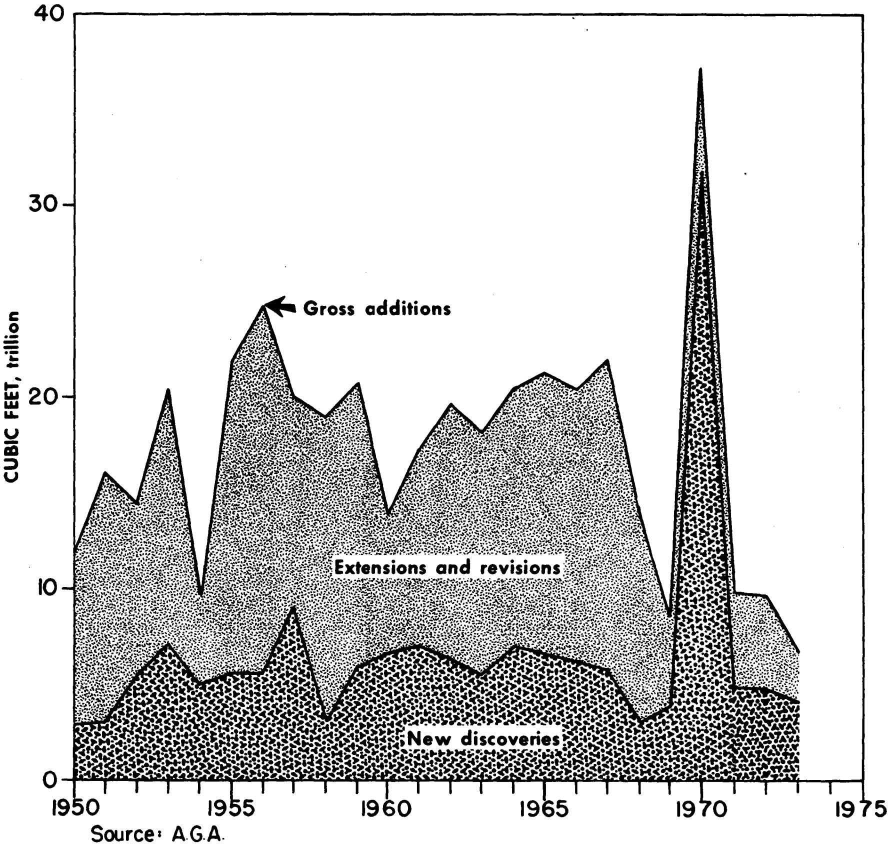

Figure 2.—Trends in annual gross additions to natural gas reserves.

In addition to exploration for new resources in the United States, American companies are involved, either independently or with Canadian companies, in exploring and drilling for oil and gas in Canada's Arctic Islands, the Maritime Provinces, and in the Mackenzie Delta. By the end of 1973, Canada's gas reserves had increased by 2.5 Tcf, which is approximately equal to current production rates. Gas reserves by the end of 1973 were calculated to be adequate for a 23-year supply. Alberta continued to be the primary supplier of oil and gas. The contribution by other areas such as the Mackenzie Delta and the Arctic Islands is anticipated to be significant by the end of the decade; by then Alberta's resources will have reached peak development.

PRODUCTIVE CAPACITY

The daily productive capacity for natural gas at the end of 1973 was estimated to be 78,231 MMcf, according to the AGA, compared with 85,998 MMcf per day as of December 31, 1972, a decline of 7,767 MMcf per day or almost 9%. Productive capacity in nonassociated gas fell to 64,160 MMcf from 69,144 MMcf. Likewise, capacity in associated-dissolved gas was reduced to 14,071 MMcf from 16,854 MMcf per day as of December 31, 1972.[4]

STORAGE

The development of additional underground storage capacity for natural gas, after slackening in 1970, moved at a faster pace in subsequent years. Total reservoir capacity increased 239 Bcf, or 4.0%, from 6.040 Tcf in 1972 to 6.279 Tcf by yearend 1973. The number of underground storage facilities expanded from 348 in 1972 to 360 in 1973. These storage facilities are located in 26 States.

Most storage reservoirs are depleted fields that originally contained dry gas. Of the 360 reservoirs, for example, 284 or nearly 79% were the dry-gas type. Most of these dry-gas reservoirs are located in the northeastern United States, primarily in the oldest petroleum provinces. The second largest concentration is found in the Midwest, in Michigan, where there are 32 such reservoirs. In Pennsylvania, where oil production dates back to 1859, some 68 dry-gas fields have been converted to storage facilities. West Virginia has 34 dry-gas reservoirs.

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[4] The productive capacity of natural gas from nonassociated reservoirs is defined as the maximum daily rate at which such gas can be produced from natural reservoirs under specified conditions on March 31 of any given year. The determination of productive capacity on March 31 of any given year is based on proved reserves of nonassociated gas reservoirs as of the preceding December 31. The productive capacity of associated-dissolved gas is based on the productive capacity of crude oil and the estimated producing gas-oil ratios that would result from such capacity operation during the first 90 days of a given year. The productive capacity of associated gas from gas wells is usually based on the volumetric withdrawal of crude oil from related oil wells at capacity rates during the first 90 days of a given year as determined by the American Petroleum Institute (API) Committee on Reserves and Productive Capacity.

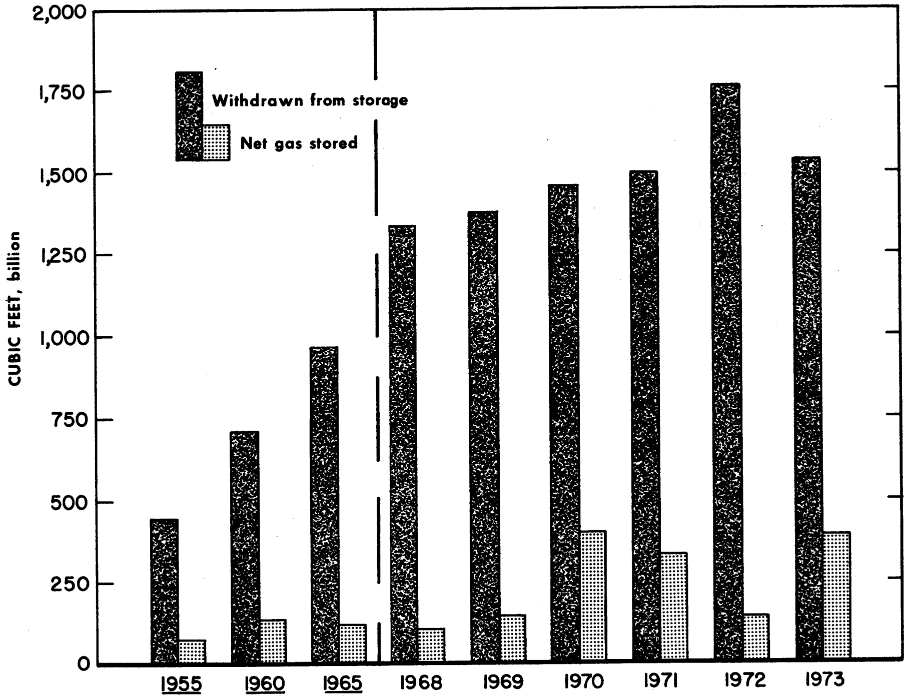

Figure 3.—Trends in net gas stored underground in U.S. storage fields.

Where depleted fields, whether oil or gas, are not available, other types of underground storage come into use. For example, there are 49 acquifers in 9 States in which natural gas is stored. Illinois is the leader with 20 acquifers. Indiana ranks second with 11. Acquifer storage accounts for 29.4% of the total storage capacity.

In addition to storage underground, there is a marked growth in the storage aboveground of natural gas liquefied by lowering temperatures. When natural gas is converted to a liquid by reducing its temperature to —258° F (—161° C) it occupies only 1/620th the space necessary for conventional vapor storage. Liquefied natural gas (LNG) storage is used for peak shaving purposes during the high-consumption, winter months.

During 1973, the total amount of gas moved into storage aggregated 1.974 Tcf as shown in table 17. Over the same period, 1.533 Tcf was drawn down, leaving a net stored of 442 Bcf for 1973.

The following table summarizes LNG facility type and storage capacity:

Facility	Status	Capacity (Bcf)	Number of plants
Peak shaving	Operational	35.571	38
Do	Under construction	13.615	12
Large satellite	Operational	5.757	18
Do	Under construction	6.400	2
Small satellite	Operational	.139	26

The development of storage reservoirs has been an important factor in meeting peak natural gas demand, particularly in the residential househeating market in which there is a high degree of seasonal variation. There is a concentration of underground storage facilities relatively close to the largest markets for residential heating. Illinois, for example, had 571 Bcf of natural gas stored in 29 reservoirs at the end of 1973. In Pennsylvania, there were 614 Bcf stored in 68 dry-gas reservoirs. These two States accounted for 1.185 Tcf or 30.3% of the total stored gas in underground reservoirs.

VALUE AND PRICE

Marketed production of natural gas again increased in value during 1973. Values totaled $4,894,072,000 as compared with a revised figure of $4,180,462,000 in 1972, or an increase of 17%. These values are based on marketed production of 22.648 Tcf in 1973 with an average value of 21.6 cents per Mcf. In 1972, marketed production totaled 22.532 Tcf with an average value of 18.6 cents per Mcf. Two States, Texas and Louisiana, accounted for 74.0% of the total marketed production. These two States plus Oklahoma and New Mexico accounted for 87% of production and 85.9% of total value.

Average values increased in those States close to markets or doing a sizable intrastate volume relative to total marketed production. In the intrastate category is Alabama where average value of gas at the wellhead advanced from 35.2 cents per Mcf to 38.2 or an increase of 8.5%. In Pennsylvania, value climbed from 30.3 cents per Mcf in 1972 to 42.0 cents in 1973 for a rise of 11.7 cents or 38.6%. In several other States relatively close to large markets, such as New York, Pennsylvania, and West Virginia, unit values also increased.

Wholesale Prices.—Increases in wholesale prices for gas also have been significant, particularly in those markets that have substantial use of gas for residential heating. The FPC collects data on the average wholesale prices in large metropolitan areas. In 12 of the 14 areas surveyed by the FPC, residential heating provides a significant market for natural gas. A 7-year historical series of average wholesale natural gas prices in the 14 large metropolitan areas, in cents per Mcf, is shown in table 19.

Comparing July 1, 1973 prices with those prevailing on July 1, 1972, wholesale rates in 11 of the 14 cities increased by 1 cent to 8 cents or more per Mcf. At the same time there were decreases in the wholesale prices for gas in Cleveland, Ohio, Pittsburgh, Pa., and Washington, D.C.

The wholesale prices for gas for those

cities cited are based on the effective FPC gas tariffs. In cities served by more than one pipeline, prices are based on weighted average charges. Prices reflect deliveries at the city gate except for Los Angeles and San Francisco, where distributors purchase gas at the California-Oregon and California-Arizona State lines.

Retail Prices.—At the retail level, the Bureau of Labor Statistics (BLS) compiles price information for fuels and energy, relative to development of the BLS Consumer Price Index. Average prices for fuels and energy are published monthly for the 20 Standard Metropolitan Statistical Areas.

At retail, gas is sold by gas utilities either in therms or in Mcf units. A therm contains 100,000 Btu. For illustrative purposes, if 1 cubic foot of natural gas contains about 1,000 Btu, 1 therm would be equivalent to about 100 cubic feet of natural gas. Since both the average wellhead value and the FPC wholesale price series are on million-cubic-foot basis, the BLS retail price series shown in table 20 has been converted from 100 therms to 10 therms so that the retail price approximates the cost of 1 Mcf.

Although retail prices of natural gas have been moving upward for some time now, significant increases are a recent development. For example, the price of gas at retail was $1.447 for 10 therms in Boston in 1965. By the end of 1970 that price was $1.568 or 8.4% higher than in 1965. Between the end of 1970 and the end of 1973, however, the retail price of gas in Boston jumped from $1.568 to $2.103, a 34.1% increase. New York prices increased from $1.363 to $1.887 or 38.4% from the end of 1970 to the end of 1973. Further increases are a foregone conclusion in light of actions taken by the FPC in Opinions and Orders related to pricing.

On June 21, 1974 the Federal Power Commission issued opinion No. 699 (R-389B) establishing a single uniform national base rate of 42¢/Mcf at standard conditions of pressure and temperature. Effective date was January 1, 1973 for new gas and new/renewed contracts on old gas.

FOREIGN TRADE

Exports of natural gas totaled 77 Bcf in 1973, and 62.6% of the total volume was shipped in liquid form from Port Nikiski, Alaska.

The LNG exports were to Japan and totaled 48.35 Bcf valued at $27,969,903, as compared with 47.88 Bcf valued at $26,694,585 in 1972.

Exports via pipeline in 1973 were almost equally divided between Canada and Mexico. Pipeline exports to Canada, nearly all of which exited at Detroit, declined 4.7% to 14.8 Bcf in 1973.

Exports of natural gas via pipelines to Mexico had been trending upward from 9.5 Bcf in 1965 to nearly 15.8 Bcf in 1971 but dropped to 14.0 Bcf in 1973.

Imports of natural gas from Canada exceeded the 1 Tcf mark for the second consecutive year in 1973. Imports from Canada by means of pipelines were 1.03 Tcf, a modest increase of 1.9%. Canadian gas imports by pipelines averaged nearly 2,814,000 Mcf per day as compared with almost 2,757,000 Mcf per day in 1972.

The value of natural gas imported from Canada increased 15.2% to $357,750,000 in 1973 from $310,521,000 in 1972, or a rise of 15.2%. This jump in value reflected the overall increase in the price of gas to 34.83 cents per Mcf in 1973 from 30.77 in 1972. Most of these price increases were on gas entering the States of Washington, Idaho, and Montana. There were nine companies importing Canadian gas in 1973.

Although imports from Canada have been growing, imports from Mexico have been decreasing drastically. Imports from Mexico entering the United States at McAllen, Tex., were 79.9% lower in 1973, primarily because supplies available for export to the United States are diminishing rapidly. From 50.97 Bcf in 1967, imports from Mexico had decreased to 1.63 Bcf by the end of 1973.

In addition to pipeline imports, 1,167,387 barrels of LNG were imported. At 14.73 psia, this volume is equivalent to 4.055 Bcf of natural gas. Algeria was the source of 83.5% of the LNG imports. The remainder originated in Canada.

The inability to obtain FPC approvals within a prescribed time resulted in cancellations of contracts for additional supplies of LNG from Algeria. Some of these contracts, however, are being renegotiated, particularly where negotiations are related to provisions on prices.

WORLD REVIEW

Marketed production of natural gas, worldwide, climbed to a record high in 1973. World production totaled 44.917 Tcf according to estimates, and of this figure, the United States accounted for 22.648 Tcf or 50.4%. In 1968, for sample comparison, the United States accounted for 61.5% of the world total marketed production.

The U.S.S.R. was second to the United States, accounting for 18.3% of world production. During 1973, marketed production in the U.S.S.R. was estimated to have been 8.33 Tcf, an increase of 516 Bcf over that of 1972. The completion of a natural gas pipeline across Czechoslovakia paved the way to move Soviet natural gas to Italy and West Germany. The new line connects the U.S.S.R. and Austria and has a flow-through capacity of 990 Bcf. Czechoslovakia will take 13%, or 129 Bcf.

Soviet natural gas began flowing to West Germany in 1973. A proposed 3,000-mile pipeline from the Tyumen gas deposits in western Siberia would carry up to 247 Bcf of gas annually to Germany and Austria by 1980.

Negotiations are under way between some U.S. companies and the U.S.S.R. wherein 2 Bcf of Siberian gas would be delivered to the east coast of the United States. This would be in exchange for financial assistance in connecting the gas reserves with seaports, a distance of about 1,800 miles, where it would be liquefied and transported by a fleet of 20 tankers. Another 2 Bcf of gas would come to the west coast of the United States from Siberian fields situated some 2,000 miles from the eastern Siberian coast. Japan is an interested party in the latter venture and could be a financial contributor and receive some of the gas. Reportedly, 10 tankers would be involved in this operation. Both of the aforementioned projects are 6 or more years distant.

The cooperation of American oil, gas, and engineering companies in assisting in the development of Soviet resources has received impetus from the discussions between the United States and the U.S.S.R. in May 1972.

In July 1972, the Occidental Petroleum Corp. signed a 5-year scientific and technical agreement covering (1) exploration, production, and usage of oil and gas, (2) agricultural fertilizers and chemicals, (3) metal treating and metal plating, and (4) the utilization of solid wastes.

Other American companies, such as El Paso Natural Gas Co., Bechtel Corporation, Texas Eastern Transmission Corp., Tenneco Corp., and Brown & Root, Inc., have been negotiating with the U.S.S.R. relative to development of its oil and gas potential.

Canadian production of natural gas, and natural gas liquids, continued at record-breaking levels through 1973. This reflects in part the sharp increase in prices for petroleum products, including natural gas liquids and synthetic products. Marketed production of natural gas rose about 8.2% during 1973 to just under 8,700 Mcf per day. This is a reduction in the growth rate, compared with that of previous years, and is due to a combination of Provincial royalty increases and Federal export control. As in past years, the bulk of production came from the Provinces of Alberta, Saskatchewan, and British Columbia, which accounted for in excess of 98% of the total production. Small quantities were also produced in Manitoba, Ontario and the Northwest Territories as well as New Brunswick. Developments throughout the world, which led to rising prices and supply shortages, had a direct bearing on the increased demand for Canadian gas by the United States. This in turn contributed to the imposition of export and price controls by the Canadian Government in a conservative move to avert anticipated shortfalls they feel could occur in supply to Canadian consumers. By yearend, a system of absolute quotas had been established, and the Government had levied export taxes which they appear to believe will bring Canadian prices more in line with world prices.

The search for gas in shallow formations continued as a priority exploration target in southern Alberta. A large amount of this activity was centered in an area called the British Block, which was formerly reserved for military testing. Approximately 8,000 square miles were made available for exploration, and considerable drilling was initiated. The area is estimated to contain upwards of 4 Tcf of gas. The first 27 tests of the scheduled 50-well drilling program have been drilled, and all were reported successful. Offshore drilling continued near Sable Island, 175 miles east of Halifax, Nova Scotia. An announcement of a new significant oil discovery was made in mid-1973 by the team of Mobil Oil Canada, and Texas Eastern Transmission Corp. This makes a total of four significant discoveries since 1966 when drilling began in this area. In the MacKenzie Delta, moderate exploration continued through 1973, with announcements of several new oil and gas finds. Very little information has been made available; however, it is felt that this area probably contains a number of major fields.

In the Arctic Islands, exploration also continued at a moderate pace; several new gas finds were made during 1973. However, there are still not enough proven reserves to warrant the building of a pipeline to transport the gas to market areas. It is hoped that continued drilling through 1974 will produce additional reserves.

Canadian Arctic Gas Study Limited (CAGSL) has not yet made any presentation before the National Energy Board (NEB) or the Federal Power Commission (FPC) for its project to move Alaska North Slope and Canadian Arctic gas to the United States and eastern Canadian markets. Resistance by the NEB to further gas-export applications is likely pending a review of gas reserves in Canada.

A major achievement in 1973 was the world's first drilling of an offshore well from a floating ice platform 8 miles off Melville Island.

In the Netherlands, marketed production in 1973 totaled 2.49 Tcf. This is 21.5% greater than that in 1972.

The Netherlands reserves of natural gas were estimated at 84.8 trillion cubic feet as of December 31, 1973. The prior estimate was 70.6 trillion cubic feet. By 1975, production is expected to plateau at from 3.0 to 3.2 Tcf per year. It is expected that about half of the gas will be exported to West Germany, France, and Belgium-Luxembourg. Some gas will go to Italy and Switzerland through a pipeline expected to be completed in 1974. The line will be 34 inches in diameter and just over 500 miles long. It will handle 211.9 billion cubic feet of gas per year.

Romania's 1973 natural gas production is estimated at about 1.03 Tcf or about 8.2% higher than the 0.95 Tcf produced in 1972. Most of the gas produced is used domestically. Industry use, for fuel and petrochemical feedstocks, is an important consumer in Romania.

The North Sea remains one of the most promising natural gas areas of the world outside the U.S.S.R. and the Middle East, and is one of the fastest developing natural gas areas in the world. Estimates of North Sea area reserves, range widely from 70 to 200 Tcf. Production from the United Kingdom gasfields in the southern North Sea have increased one-third from 2,426,000 Mcf per day in 1972 to 3,250,000 Mcf per day in 1973. Exploratory drilling and geological surveys continued in the North Sea waters of Norway, Denmark, West Germany, the Netherlands, and the United Kingdom. The area of interest has expanded to include the Celtic Sea south of Ireland. the Atlantic Ocean north of Scotland, and the Baltic Sea south of Sweden. A newly developed gasfield south of Cork, Ireland, is believed to contain 1 Tcf of natural gas.

Of the 576 wells completed in the North Sea by the end of 1973, 135 were drilled in the last year. The majority of these, 473, are exploratory. By the winter of 1973–74, 38 or more jackup and semisubmersible drilling rigs were operating in the North Sea and adjacent waters. Future drilling should quicken since 50 of the 90 drilling rigs now under construction are slated for North Sea use.

Algeria's marketed production is becoming a progressively more important factor to the United States in view of long-range plans to import natural gas as LNG. El Paso Natural Gas Co.'s plans to import 1 Bcf per day of gas are proceeding, and deliveries are scheduled to start in April 1976. Negotiations on a second agreement were in progress at yearend 1973. A contract already in effect involves imports of 42 MMcf per day by Distrigas of Boston. A third company, Eascogas LNG, Inc., has been granted conditional approval by the FPC to import up to 0.652 Bcf per day.

Algerian sources estimate that nation's gas reserves at 150 Tcf. Further, by 1976 they believe natural gas will be one of Algeria's most important sources of foreign income. U.S. imports of Algerian LNG increased by 66.8%, from 2.032 Bcf in 1972 to 3.388 Bcf in 1973. In addition, Algeria's state-owned company Société Nationale pour las Recherche la Production, le Transport, la Transformation et la Commercialisation des Hydrocarbures (Sonatrach) has been negotiating with companies from West Germany, Belgium, France, Spain, and Britain to provide Europe with long-term supplies of LNG. West Germany is showing interest in financing port facilities to enhance their receiving Algerian LNG.

TECHNOLOGY

The expected long-term scarcity of natural gas has stimulated action on the part of industry and Government to spearhead research in the development of gasification of coal to obtain a high-Btu gas that is virtually the same in characteristics as pipeline-quality natural gas.

Construction of a $12 million Synthane process facility at Bruceton, Pa., to develop the Bureau of Mines coal gasification process is expected to be completed in August 1974. This pilot plant will be the fourth in a series to evaluate coal gasification for high-Btu gas. Currently, plants consist of the Institute of Gas Technology's HYGAS process at Chicago, Ill., and Consolidation Coal Co.'s CO_2-Acceptor process at Rapid City, S. Dak. The third pilot coal gasification plant is being built under a 1971 agreement between the Office of Coal Research and the AGA at Homer City, Pa., and is scheduled for completion in 1974. It will incorporate Bituminous Coal Research's BI-GAS process. A high-Btu gas is to be the end product, although the plant will have built-in design capability to produce low-Btu gas. The Synthane gasifier is designed to operate at 1,000 pounds per square inch and 1,800° F, and to produce 100,000 standard cubic feet per hour (scfh) of coal gas. One-fourth of the raw gas will be further processed to produce 13,000 scfh of pipeline-quality gas. A commercial plant would have a capacity of 250,000 Mcf of pipeline-quality gas per day.

In the low-Btu gas category, a Westinghouse-led team is working to develop the process. A pilot plant is scheduled to be built to handle 15 tons of coal per day and should be completed in 1974.

There are 47 SNG plants in various stages ranging from operational to those projects which have been cancelled. Three plants are operational with work in progress on 19, planning underway on 4, and 21 either suspended or cancelled. The three operational plants have a capacity of 340,000 Mcf per day. Plants now nearing completion and in startup will add another 896,000 Mcf per day.

Subsurface nuclear detonation is another method for augmenting the supply of natural gas. The Atomic Energy Commission has conducted three experiments to determine the feasibility of using nuclear stimulation in the recovery of natural gas in tight formations. The first, the 1967 Gas Buggy experiment in New Mexico, was a 29-kiloton shot. The second, a 43-kiloton shot, was at Rulison, Colo. in 1969. Both proved that the flow of gas could be stimulated, but there was some tritium contamination.

The third experiment, also in Colorado, was the Project Rio Blanco Phase I. This was the near simultaneous detonation of three 30-kiloton nuclear explosives spaced one above the other more than 1 mile underground. The detonation took place on May 17, 1973. Production testing by flaring gas started on November 14, 1973. Results indicated only the top cavity was open to the production well which was drilled to evaluate the results of the stimulation. Production was disappointing with a rapid pressure drop occurring within a very short period of gas flaring. A directed hole is being drilled with the middle cavity as the objective. Status of the lowermost cavity is completely unknown.

Table 2.—Gas pipeline failures reported during 1972–73 [1]

	Total number of failures		Fatalities: Employees		Fatalities: Non-employees		Injuries: Employees		Injuries: Non-employees		Estimated property damage (value)	
	1972	1973	1972	1973	1972	1973	1972	1973	1972	1973	1972	1973
Distribution system:												
Corrosion	121	133	--	1	2	2	9	--	56	69		
Damage by outside forces	630	602	--	--	20	16	15	13	141	133		
Construction defect or material failure	90	92	1	--	3	11	3	10	52	53	$574,146	$517,619
Other causes	43	66	1	--	1	3	5	25	13	30		
Total	884	893	2	1	26	32	32	48	262	285	574,146	517,619
Transmission system:												
Corrosion	74	63	--	--	--	--	--	1	--	--		
Damage by outside forces	219	272	--	--	--	--	8	--	4	15		
Construction defect or material failure	80	111	--	--	2	--	4	--	1	--	2,424,747	6,283,996
Other causes	36	25	3	1	1	1	11	2	8	1		
Total	409	471	3	1	3	1	23	3	13	16	2,424,747	6,283,996
Grand total	1,293	1,364	5	2	29	33	55	51	275	301	2,998,893	6,801,615

[1] In addition to this table compiled from written gas pipeline failure reports received by the Office of Pipeline Safety during 1973, there were 7 fatalities and 25 injuries resulting from gas distribution incidents that occurred in 1973 but were not reported until after December 31. Also, additional incidents reported to OPS by telephonic notice during 1973, but which did not require followup written reports, indicated that there were 17 fatalities and 47 injuries from distribution system failures.

Source: Office of Pipeline Safety, Department of Transportation.

Table 3.—Gross withdrawals and disposition of natural gas in the United States

(Million cubic feet at 14.73 psia)

State	Gross withdrawals			Disposition		
	From gas wells	From oil wells	Total [1]	Marketed production	Repressuring	Vented and flared [2]
1972						
Alabama	2,601	2,009	4,610	3,644	--	966
Alaska	126,198	96,707	222,905	125,596	75,719	21,590
Arizona	431	378	809	442	--	367
Arkansas	125,319	43,852	169,171	166,522	--	2,649
California	304,049	251,343	555,392	487,278	68,114	--
Colorado	94,401	27,721	122,122	116,949	415	4,758
Florida	--	15,805	15,805	15,521	--	284
Illinois	1,194	1,806	3,000	1,194	--	1,806
Indiana	355	--	355	355	--	--
Kansas	751,921	141,815	893,736	889,268	1,787	2,681
Kentucky	63,648	--	63,648	63,648	--	--
Louisiana	6,924,204	1,235,559	8,159,763	7,972,678	123,418	63,667
Maryland	244	--	244	244	--	--
Michigan	13,523	21,730	35,253	34,221	--	1,032
Mississippi	94,320	25,377	119,697	103,989	12,036	3,672
Missouri	9	--	9	9	--	--
Montana	34,958	3,179	38,137	33,474	441	4,222
Nebraska	2,779	1,962	4,741	3,478	--	1,263
New Mexico	944,463	277,294	1,221,757	1,216,061	--	5,696
New York	3,679	--	3,679	3,679	--	--
North Dakota	r 597	r 52,661	r 53,258	32,472	--	r 20,786
Ohio	72,765	17,230	89,995	89,995	--	--
Oklahoma	1,435,726	492,223	1,927,949	1,806,887	82,265	38,797
Pennsylvania	71,498	2,460	73,958	73,958	--	--
South Dakota	8	--	8	--	8	--
Tennessee	25	180	205	25	--	180
Texas	7,409,894	2,140,575	9,550,469	8,657,840	832,808	59,821
Utah	25,783	49,881	75,664	39,474	30,684	5,506
Virginia	2,787	--	2,787	2,787	--	--
West Virginia	213,845	1,291	215,136	214,951	185	--
Wyoming	321,368	70,479	391,847	375,059	8,412	8,376
Total	r 19,042,592	r 4,973,517	r 24,016,109	22,531,698	1,236,292	r 248,119
1973						
Alabama	8,148	5,013	13,161	11,271	--	1,890
Alaska	123,986	99,302	223,288	131,007	87,302	4,979
Arizona	139	263	402	125	--	277
Arkansas	120,068	39,408	159,476	157,529	--	1,947
California	291,984	221,602	513,586	449,369	62,218	1,999
Colorado	105,541	35,901	141,442	137,725	709	3,008
Florida	--	33,857	33,857	33,857	--	--
Illinois	1,638	--	1,638	1,638	--	--
Indiana	276	--	276	276	--	--
Kansas	745,662	151,627	897,289	893,118	1,794	2,377
Kentucky	62,396	--	62,396	62,396	--	--
Louisiana	7,347,732	1,143,462	8,491,194	8,242,423	146,680	102,091
Maryland	298	--	298	298	--	--
Michigan	23,272	22,424	45,696	44,579	--	1,117
Mississippi	90,776	26,985	117,761	99,706	7,288	10,767
Missouri	33	--	33	33	--	--
Montana	55,329	5,602	60,931	56,175	1,065	3,691
Nebraska	2,610	2,060	4,670	3,836	--	834
New Mexico	954,632	268,930	1,223,562	1,218,749	1,022	3,791
New York	4,539	--	4,539	4,539	--	--
North Dakota	282	49,954	50,236	27,703	--	22,533
Ohio	76,931	16,679	93,610	93,610	--	--
Oklahoma	1,455,293	434,494	1,889,787	1,770,980	82,396	36,411
Pennsylvania	76,234	2,280	78,514	78,514	--	--
South Dakota	10	--	10	--	10	--
Tennessee	20	165	185	20	--	165
Texas	7,282,804	2,007,141	9,289,945	8,513,850	739,962	36,133
Utah	22,849	55,662	78,511	42,715	28,132	7,664
Virginia	5,101	--	5,101	5,101	--	--
West Virginia	207,702	1,114	208,816	208,676	140	--
Wyoming	305,315	71,677	376,992	357,731	12,643	6,618
Total	19,371,600	4,695,602	24,067,202	22,647,549	1,171,361	248,292

r Revised.
[1] Marketed production plus quantities used in repressuring and vented and flared.
[2] Partly estimated; includes direct losses on producing properties and residue blown to the air.

Source: Figures based on reports received from State agencies and Bureau of Mines estimates.

Table 4.—Gas and oil well completions in the United States, by State, 1968–73

State	Gas completions [1]						Oil completions [2]					
	1968	1969	1970	1971	1972	1973	1968	1969	1970	1971	1972	1973
Alabama	1	1	5	6	9	10	9	10	7	8	13	18
Alaska	7	11	5	1	2	3	77	38	67	27	12	20
Arizona	--	2	--	2	1	1	4	9	1	--	5	--
Arkansas	46	40	36	29	39	40	103	151	100	127	96	91
California	77	59	56	60	62	65	2,191	1,543	1,697	1,459	1,045	879
Colorado	50	47	47	148	124	148	108	158	142	154	300	228
Florida	--	--	--	--	--	--	3	6	14	8	65	24
Illinois	1	5	5	16	18	13	544	417	311	252	255	240
Indiana	14	7	4	2	5	8	122	129	93	81	92	67
Kansas	90	184	108	112	368	384	1,210	1,271	1,044	1,099	880	592
Kentucky	205	142	111	135	166	157	383	296	275	244	230	158
Louisiana:												
North	143	123	157	237	451	269	310	309	263	390	291	234
South	210	230	232	200	234	284	560	471	497	398	375	337
Offshore	184	190	150	184	133	231	476	372	382	258	253	287
Total Louisiana	537	543	539	621	818	784	1,346	1,152	1,142	1,046	919	858
Michigan	28	15	19	33	34	41	73	73	49	81	87	73
Mississippi	12	16	12	13	13	28	161	195	211	175	87	70
Missouri	--	--	--	1	--	--	12	17	10	6	--	--
Montana	40	31	74	33	125	123	319	186	64	45	83	46
Nebraska	--	1	2	1	2	--	64	57	39	47	48	33
New Mexico	150	263	159	186	238	498	512	561	341	401	502	280
New York	10	12	17	7	22	27	83	112	69	83	96	97
North Dakota	--	--	1	1	--	--	49	49	48	49	23	40
Ohio	230	395	683	608	721	940	726	645	503	391	426	393
Oklahoma	370	397	321	238	341	539	1,323	1,604	1,343	1,174	1,025	898
Pennsylvania	253	277	250	199	297	434	472	547	441	394	534	525
South Dakota	--	--	--	--	--	--	--	--	--	2	4	5
Tennessee	6	7	4	23	9	10	--	4	24	57	14	24
Texas	763	903	774	810	943	1,475	3,779	4,256	4,137	3,880	3,963	3,686
Utah	5	16	10	6	13	25	38	47	29	30	73	104
Virginia	--	--	--	--	18	7	--	1	--	--	--	--
West Virginia	522	652	553	496	488	514	119	135	192	133	84	72
Wyoming	39	57	45	43	52	61	501	699	627	405	345	381
Grand total	3,456	4,083	3,840	3,830	4,928	6,335	14,331	14,368	13,020	11,858	11,306	9,902

[1] Includes multiple completion wells that produce gas from all zones.
[2] Includes multiple completion wells that produce gas from one or more zones but oil from at least one zone.

Source: American Petroleum Institute Quarterly Review of Drilling Statistics for the United States, Annual Summaries 1968 to 1973, inclusive.

Table 5.—Exploratory wells drilled in the United States

State	Gas completions [1]						Oil completions [2]					
	1968	1969	1970	1971	1972	1973	1968	1969	1970	1971	1972	1973
Alabama	1	--	1	2	6	5	--	3	2	3	2	4
Alaska	1	--	1	--	1	1	3	--	23	1	--	2
Arizona	--	--	--	1	1	1	1	1	--	--	--	--
Arkansas	8	5	4	2	1	2	4	11	7	9	7	4
California	7	7	8	5	9	17	20	24	28	21	17	17
Colorado	5	14	15	27	29	29	16	46	26	29	71	38
Florida	--	--	--	--	--	--	--	1	2	--	2	3
Illinois	--	1	2	4	2	1	21	31	16	24	20	22
Indiana	3	5	3	1	3	3	20	25	8	14	11	11
Kansas	22	25	--	14	26	40	171	173	131	131	117	98
Kentucky	38	20	26	12	18	16	50	29	21	23	30	18
Louisiana:												
North	6	8	10	10	12	4	11	12	9	8	8	1
South	44	73	48	37	62	48	42	29	25	22	16	21
Offshore	43	12	11	25	5	2	32	16	6	13	--	--
Total Louisiana	93	93	69	72	79	54	85	57	40	43	24	22
Michigan	4	3	7	13	21	31	13	7	9	26	34	38
Mississippi	--	3	2	3	4	15	26	30	25	13	9	13
Missouri	--	--	--	--	--	--	--	2	--	--	--	--
Montana	15	9	20	16	29	28	27	23	21	4	15	10
Nebraska	--	--	--	--	--	--	25	17	10	7	10	7
New Mexico	8	11	8	7	27	25	29	26	16	6	14	9
New York	1	1	2	3	3	3	--	--	--	--	1	2
North Dakota	--	--	--	--	--	--	5	15	7	8	7	4
Ohio	14	24	17	7	24	31	28	5	1	--	2	--
Oklahoma	39	57	43	27	55	69	52	110	59	42	37	35
Pennsylvania	13	10	21	3	20	41	11	4	2	1	3	3
South Dakota	--	--	--	--	--	--	--	--	--	2	--	4
Tennessee	6	6	1	14	7	8	--	3	5	16	4	6
Texas	158	264	179	172	183	410	267	330	256	186	179	207
Utah	1	6	4	4	2	13	2	8	9	8	22	4
Virginia	--	--	--	--	--	2	--	--	--	--	--	--
West Virginia	40	37	31	18	35	39	3	2	--	1	1	4
Wyoming	9	15	7	10	16	16	75	101	66	33	45	34
Grand total	486	616	471	437	601	900	954	1,084	790	651	684	619

[1] Includes multiple completion wells that produce gas from all zones.

[2] Includes multiple completion wells that produce gas from one or more zones but oil from at least one zone.

Source: American Petroleum Institute Quarterly Review of Drilling Statistics for the United States, Annual Summaries 1968 to 1973, inclusive.

Table 6.—Producing wells and condensate wells in the United States

PAD district and State	Producing as of Dec. 31, 1968 [1]	Producing as of Dec. 31, 1969 [1]	Producing as of Dec. 31, 1970 [1]	Producing as of Dec. 31, 1971 [1]	Producing as of Dec. 31, 1972 [1]	Producing as of Dec. 31, 1973 [1]
District 1:						
Maryland	15	13	16	14	16	15
New York	1,155	818	600	600	650	789
Pennsylvania	17,000	16,600	16,239	16,586	16,600	16,600
Virginia	111	111	115	115	130	178
West Virginia	18,214	18,600	20,702	21,025	21,324	21,400
Total	36,495	36,142	37,672	38,340	38,720	38,982
District 2:						
Illinois	5	5	8	14	31	36
Indiana	265	263	50	83	87	106
Kansas	8,509	8,567	8,660	8,585	8,621	8,785
Kentucky	6,290	6,413	6,913	7,413	7,099	7,224
Michigan	199	211	1,235	1,171	1,317	1,145
Missouri	11	11	11	2	3	2
Nebraska	36	35	35	29	29	29
North Dakota	19	33	29	29	21	44
Ohio	7,211	7,334	7,789	8,179	8,630	9,406
Oklahoma	8,337	8,432	8,168	8,507	8,457	8,868
Tennessee	23	26	15	20	45	6
Total	30,905	31,330	32,913	34,032	34,340	35,651
District 3:						
Alabama	1	1	2	--	15	15
Arkansas	947	998	1,008	1,013	1,041	876
Louisiana	9,163	9,354	9,690	9,748	9,456	10,551
Mississippi	347	322	325	400	252	250
New Mexico	8,754	9,100	8,848	9,388	9,679	9,711
Texas	23,805	23,689	23,417	23,280	23,373	23,805
Total	43,017	43,464	43,290	43,829	43,816	45,208
District 4:						
Colorado	810	805	861	928	934	1,050
Montana	1,196	1,098	739	1,056	1,116	1,118
Utah	165	171	173	178	200	158
Wyoming	787	521	800	840	887	850
Total	2,958	2,595	2,573	3,002	3,137	3,176
District 5:						
Alaska	18	44	51	40	50	52
Arizona	4	4	4	5	4	4
California	994	897	980	962	1,086	1,095
Total	1,016	945	1,035	1,007	1,140	1,151
Total United States	114,391	144,476	117,483	120,210	121,153	124,168

[1] Based on State estimates and State reports.

Table 7.—Consumption of natural gas by use and by State, 1973

(Million cubic feet at 14.73 psia)

Region and State	Delivered to consumers		Extraction loss		Lease and plant fuel		Pipeline fuel		Total	
	Quantity (million cubic feet)	Value (thousand dollars)	Quantity (million cubic feet)	Value (thousand dollars)	Quantity (million cubic feet)	Value (thousand dollars)	Quantity (million cubic feet)	Value (thousand dollars)	Quantity (million cubic feet)	Value (thousand dollars)
New England:										
Connecticut	62,584	117,370	--	--	--	--	25	10	62,609	117,380
Maine, New Hampshire, Vermont	13,881	23,326	--	--	--	--	--	--	13,881	23,326
Massachusetts	154,967	309,915	--	--	--	--	580	222	155,547	310,137
Rhode Island	20,540	41,813	--	--	--	--	19	8	20,559	41,821
Total	251,972	492,424	--	--	--	--	624	240	252,596	492,664
Middle Atlantic:										
New Jersey	300,886	461,929	--	--	--	--	680	169	301,566	462,098
New York	679,079	945,861	--	--	442	244	3,026	825	682,547	946,930
Pennsylvania	758,187	832,526	71	28	2,725	1,322	22,385	7,235	783,368	841,111
Total	1,738,152	2,240,316	71	28	3,167	1,566	26,091	8,229	1,767,481	2,250,139
East North Central:										
Illinois	1,128,649	1,044,700	13,534	3,289	246	78	21,371	5,693	1,163,800	1,053,760
Indiana	529,604	435,546	--	--	--	--	12,696	3,380	542,300	438,926
Michigan	905,777	837,059	1,581	531	2,551	749	12,023	4,160	921,932	842,499
Ohio	1,087,810	972,041	--	--	3,548	1,600	12,798	3,879	1,104,156	977,520
Wisconsin	362,541	347,835	--	--	--	--	5,420	1,474	367,961	349,309
Total	4,014,381	3,637,181	15,115	3,820	6,345	2,427	64,308	18,586	4,100,149	3,662,014
West North Central:										
Iowa	348,156	257,517	--	--	--	--	16,484	3,570	364,640	261,087
Kansas	498,865	232,932	43,909	8,079	32,663	8,950	72,932	17,530	648,369	267,491
Minnesota	355,372	288,401	--	--	--	--	5,439	1,496	360,811	289,897
Missouri	417,638	326,911	--	--	--	--	9,169	2,414	426,807	329,325
Nebraska	214,226	135,001	474	93	1,809	429	13,597	2,543	230,106	138,066
North Dakota	19,952	18,982	2,969	888	12,462	2,327	14	4	35,397	22,201
South Dakota	31,209	25,367	--	--	--	--	12	4	31,221	25,371
Total	1,885,418	1,285,111	47,352	9,060	46,934	11,706	117,647	27,561	2,097,351	1,333,438
South Atlantic:										
Delaware	22,949	27,674	--	--	--	--	--	--	22,949	27,674
Florida	304,587	213,166	2,886	1,229	3,027	887	3,884	1,169	314,384	216,451
Georgia	341,971	277,914	--	--	--	--	6,118	1,560	348,089	279,474
Maryland and District of Columbia	199,153	250,505	--	--	474	289	2,334	572	201,961	251,366
North Carolina	154,879	138,737	--	--	--	--	5,992	1,407	160,871	140,144
South Carolina	149,623	123,192	--	--	--	--	3,524	906	153,147	124,098
Virginia	146,850	166,192	--	--	170	66	5,828	1,620	152,848	167,878
West Virginia	166,624	127,783	9,428	3,045	2,160	773	17,532	6,903	195,744	138,504
Total	1,486,636	1,325,163	12,314	4,274	5,831	2,015	45,212	14,137	1,549,993	1,345,589

Table 7.—Consumption of natural gas by use and by State, 1973—Continued

(Million cubic feet at 14.73 psia)

Region and State	Delivered to consumers: Quantity (million cubic feet)	Delivered to consumers: Value (thousand dollars)	Extraction loss: Quantity (million cubic feet)	Extraction loss: Value (thousand dollars)	Lease and plant fuel: Quantity (million cubic feet)	Lease and plant fuel: Value (thousand dollars)	Pipeline fuel: Quantity (million cubic feet)	Pipeline fuel: Value (thousand dollars)	Total: Quantity (million cubic feet)	Total: Value (thousand dollars)
East South Central:										
Alabama	250,944	177,547	199	41	1,329	522	19,795	5,186	272,267	183,296
Kentucky	209,556	163,022	5,441	1,241	1,238	329	34,678	8,724	250,913	173,316
Mississippi	250,464	134,582	878	215	6,152	1,255	57,376	13,924	314,870	149,976
Tennessee	263,901	174,912	--	--	1,263	446	28,456	6,952	293,620	182,310
Total	974,865	650,063	6,518	1,497	9,982	2,552	140,305	34,786	1,131,670	688,898
West South Central:										
Arkansas	309,380	151,869	1,118	299	3,000	726	15,423	3,948	328,921	156,842
Louisiana	1,592,829	635,545	206,833	73,219	336,832	78,819	80,198	19,568	2,216,692	807,151
Oklahoma	505,444	214,300	61,647	15,350	80,233	13,720	26,061	5,758	673,385	249,128
Texas	3,688,652	1,377,525	466,143	168,744	828,139	160,659	104,587	21,336	5,087,521	1,728,264
Total	6,096,305	2,379,239	735,741	257,612	1,248,204	253,924	226,269	50,610	8,306,519	2,941,385
Mountain:										
Arizona	190,300	131,394	--	--	39	8	23,984	5,186	214,323	136,588
Colorado	314,225	181,605	4,674	1,154	7,202	1,548	2,580	567	328,681	184,874
Idaho	51,396	44,058	--	--	--	--	4,649	1,568	56,045	45,626
Montana	84,286	58,862	918	213	4,281	831	1,663	349	91,148	60,255
Nevada	73,072	55,029	--	--	--	--	--	--	73,072	55,029
New Mexico	174,742	86,513	55,782	12,439	52,553	9,261	29,516	6,375	312,593	114,588
Utah	120,060	79,506	3,489	928	2,435	441	611	178	126,595	81,053
Wyoming	78,719	33,825	16,093	3,975	21,151	3,405	8,729	2,078	124,692	43,283
Total	1,086,800	670,792	80,956	18,709	87,661	15,494	71,732	16,301	1,327,149	721,296
Pacific:										
Alaska	47,686	35,477	986	279	15,217	3,485	170	48	64,059	39,289
California	1,953,313	1,463,493	17,498	8,697	72,574	25,836	19,740	7,778	2,063,125	1,505,804
Oregon	99,245	102,625	--	--	--	--	8,716	3,008	107,961	105,633
Washington	190,498	161,511	--	--	--	--	7,363	2,414	197,861	163,925
Total	2,290,742	1,763,106	18,484	8,976	87,791	29,321	35,989	13,248	2,433,006	1,814,651
Total United States	19,825,271	14,443,395	916,551	303,976	1,495,915	319,005	728,177	183,698	22,965,914	15,250,074

Tabel 8.—Quantity and value of natural gas delivered

(Million cubic feet

Region and State	Residential			Commercial		
	Number of consumers (thousands)	Quantity (million cubic feet)	Value (thousand dollars)	Number of consumers (thousands)	Quantity (million cubic feet)	Value (thousand dollars)
New England:						
Connecticut	361	30,261	67,996	30	14,190	26,517
Maine, Vermont, New Hampshire	69	6,027	13,100	5	3,234	5,582
Massachusetts	1,023	83,988	201,655	67	34,263	65,063
Rhode Island	150	11,417	27,090	9	3,666	7,200
Total	1,603	131,693	309,841	111	55,353	104,362
Middle Atlantic:						
New Jersey	1,619	136,625	284,590	183	59,043	92,698
New York	3,878	342,608	596,481	262	123,582	174,705
Pennsylvania	2,216	292,531	433,238	149	108,022	126,346
Total	7,713	771,764	1,314,309	594	290,647	393,749
East North Central:						
Illinois	2,871	445,723	540,457	217	212,922	190,661
Indiana	1,065	155,039	185,272	107	74,066	73,318
Michigan	2,043	341,607	403,779	177	172,202	166,750
Ohio	2,577	439,212	487,525	208	185,033	172,081
Wisconsin	830	110,524	157,994	70	51,764	59,253
Total	9,386	1,492,105	1,775,027	779	695,987	662,063
West North Central:						
Iowa	614	91,310	106,833	64	59,892	55,280
Kansas	617	96,468	72,062	58	48,902	26,749
Minnesota	649	102,671	133,883	59	53,384	51,550
Missouri	1,059	153,543	178,263	76	75,632	64,136
Nebraska	326	50,383	52,449	49	36,571	28,269
North Dakota	54	8,204	9,385	8	9,875	8,621
South Dakota	80	11,190	13,364	10	9,854	7,706
Total	3,399	513,769	566,239	324	294,110	242,311
South Atlantic:						
Delaware	78	7,514	13,921	5	3,093	4,287
Florida	384	16,295	44,029	29	19,442	29,007
Georgia	799	86,191	112,336	61	43,663	41,043
Maryland and District of Columbia	859	86,670	145,679	65	37,308	48,214
North Carolina	288	28,435	42,795	42	17,903	22,450
South Carolina	255	22,758	37,596	25	14,743	15,493
Virginia	481	51,618	86,670	41	27,650	34,563
West Virginia	369	55,686	54,238	33	23,993	18,259
Total	3,513	355,167	537,264	301	187,795	213,316
East South Central:						
Alabama	603	55,685	76,177	41	32,131	23,809
Kentucky	588	80,233	79,350	58	38,585	31,871
Mississippi	337	31,422	34,218	34	15,316	11,151
Tennessee	431	45,993	49,557	54	41,759	39,212
Total	1,959	213,333	239,302	187	127,791	106,043
West South Central:						
Arkansas	412	48,883	42,626	51	31,360	19,857
Louisiana	893	93,072	90,559	68	28,730	19,450
Oklahoma	654	73,744	67,771	62	36,582	23,815
Texas	2,616	241,478	250,896	233	103,374	68,950
Total	4,575	457,177	451,852	414	200,046	132,072

See footnotes at end of table.

to consumers in 1973, by type of consumer and by State
at 14.73 psia)

Industrial [1]		Electric utilities		Other consumers [2]		Total	
Quantity (million cubic feet)	Value (thousand dollars)	Quantity (million cubic feet)	Value (thousand dollars)	Quantity (million cubic feet)	Value (thousand dollars)	Quantity (million cubic feet)	Value (thousand dollars)
16,903	21,281	--	--	1,230	1,576	62,584	117,370
3,775	4,178	756	387	89	79	13,881	23,326
26,349	34,201	5,342	2,906	5,025	6,090	154,967	309,915
4,445	5,943	30	17	982	1,563	20,540	41,813
51,472	65,603	6,128	3,310	7,326	9,308	251,972	492,424
78,348	68,163	24,067	13,117	2,803	3,361	300,886	461,929
124,203	112,901	69,532	40,954	19,154	20,820	679,079	945,861
346,121	263,398	3,270	1,903	8,243	7,641	758,187	832,526
548,672	444,462	96,869	55,974	30,200	31,822	1,738,152	2,240,316
424,573	289,559	39,823	20,350	5,608	3,673	1,128,649	1,044,700
287,485	169,616	10,245	4,989	2,769	2,351	529,604	435,546
337,484	234,214	46,412	26,084	8,072	6,232	905,777	837,059
435,844	293,323	16,091	9,285	11,630	9,827	1,087,810	972,041
167,338	113,623	29,667	15,279	3,248	1,686	362,541	347,835
1,652,724	1,100,335	142,238	75,987	31,327	23,769	4,014,381	3,637,181
131,649	68,194	61,847	25,543	3,458	1,667	348,156	257,517
173,549	62,478	176,174	70,293	3,772	1,350	498,865	232,932
115,821	63,007	56,661	23,344	26,835	16,617	355,372	288,401
118,795	54,764	54,262	22,844	15,406	6,904	417,638	326,911
71,053	31,263	54,100	21,965	2,119	1,055	214,226	135,001
1,524	828	349	148	--	--	19,952	18,982
5,391	2,194	4,060	1,713	714	390	31,209	25,367
617,782	282,728	407,453	165,850	52,304	27,983	1,885,418	1,285,111
10,032	8,156	2,310	1,310	--	--	22,949	27,674
95,669	55,584	168,308	82,134	4,873	2,412	304,587	213,166
174,135	106,571	34,392	14,823	3,590	3,141	341,971	277,914
60,660	47,012	8,870	3,752	5,645	5,848	199,153	250,505
95,652	65,235	7,748	4,517	5,141	3,740	154,879	138,737
85,707	55,538	25,105	13,732	1,310	833	149,623	123,192
53,428	35,156	4,172	1,907	9,982	7,896	146,850	166,192
84,690	53,693	394	162	1,861	1,431	166,624	127,783
659,973	426,945	251,299	122,337	32,402	25,301	1,486,636	1,325,163
159,756	76,044	2,377	918	995	599	250,944	177,547
75,459	43,313	8,067	3,453	7,212	5,035	209,556	163,022
135,498	58,942	59,843	25,014	8,385	35,975	250,464	165,300
159,949	79,495	11,985	4,039	4,215	2,609	263,901	174,912
530,662	257,794	82,272	33,424	20,807	44,218	974,865	680,781
178,429	70,479	48,279	17,912	2,429	995	309,380	151,869
1,085,216	410,212	355,023	104,377	30,788	10,947	1,592,829	635,545
138,563	50,160	252,734	70,513	3,821	2,041	505,444	214,300
2,031,210	635,769	1,260,894	404,747	51,696	17,163	3,688,652	1,377,525
3,433,418	1,166,620	1,916,930	597,549	88,734	31,146	6,096,305	2,379,239

Table 8.—Quantity and value of natural gas delivered to consumers

(Million cubic feet

Region and State	Residential			Commercial		
	Number of consumers (thousands)	Quantity (million cubic feet)	Value (thousand dollars)	Number of consumers (thousands)	Quantity (million cubic feet)	Value (thousand dollars)
Mountain:						
Arizona	491	36,280	49,631	38	29,475	22,932
Colorado	639	98,454	81,262	78	66,144	45,999
Idaho	86	9,947	15,129	13	7,845	9,022
Montana	155	24,923	27,066	21	16,786	13,513
Nevada	88	9,048	13,916	4	8,942	8,870
New Mexico	220	23,730	23,812	24	11,945	8,419
Utah	261	48,647	48,015	16	8,982	7,141
Wyoming	81	13,868	10,610	10	12,348	6,680
Total	2,021	264,897	269,441	204	162,467	122,576
Pacific:						
Alaska	23	5,024	7,908	3	5,681	6,442
California	5,938	615,719	714,850	352	223,420	193,258
Oregon	224	22,271	39,228	28	13,434	19,746
Washington	291	36,468	56,598	38	31,310	39,638
Total	6,476	679,482	818,584	421	273,845	259,084
Total United States	40,645	4,879,387	6,281,859	3,335	2,288,041	2,235,576

[1] Includes refinery fuel use of 1,073,742 MMcf and 49,682 MMcf for carbon black production.
[2] Includes deliveries to municipalities and public authorities for institutional heating, street lighting, etc.

Source: Federal Power Commission.

in 1973, by type of consumer and by State—Continued

at 14.73 psia)

Industrial[1]		Electric utilities		Other consumers[2]		Total	
Quantity (million cubic feet)	Value (thousand dollars)	Quantity (million cubic feet)	Value (thousand dollars)	Quantity (million cubic feet)	Value (thousand dollars)	Quantity (million cubic feet)	Value (thousand dollars)
65,707	32,262	56,501	25,143	2,337	1,426	190,300	131,394
87,325	32,747	58,602	19,925	3,700	1,672	314,225	181,605
32,062	18,885	--	--	1,542	1,022	51,396	44,058
37,898	16,145	2,322	820	2,357	1,318	84,286	58,862
10,342	8,201	40,538	21,445	4,202	2,597	73,072	55,029
60,318	22,981	65,125	26,311	13,624	4,990	174,742	86,513
58,114	22,897	4,302	1,441	15	12	120,060	79,506
50,861	15,970	784	263	858	302	78,719	33,825
402,627	170,088	228,174	95,348	28,635	13,339	1,086,800	670,792
14,985	10,864	15,400	7,176	6,596	3,087	47,686	35,477
649,757	346,320	455,063	204,323	9,354	4,742	1,953,313	1,463,493
59,745	41,762	3,507	1,704	288	185	99,245	102,625
121,697	64,621	--	--	1,023	654	190,498	161,511
846,184	463,567	473,970	213,203	17,261	8,668	2,290,742	1,763,106
8,743,514	4,378,142	3,605,333	1,362,982	308,996	215,554	19,825,271	14,474,113

Table 9.—Production of natural gas liquids at natural gas processing plants, and disposition of residue gas in the United States in 1972–73, by State

(Million cubic feet at 14.73 psia at 60° F unless otherwise stated)

State	Total natural gas liquids and ethane production (thousand 42-gallon barrels)	Natural gas processed	Extraction loss (shrinkage)	Disposition of residue gas: Used at plants	Returned to formation	Vented or flared	Shipped to transmission companies	Direct deliveries to consumers	Unaccounted for	Total
1972										
Arkansas	807	r 28,027	1,197	3,056	241	14	r 20,257	3,262	--	r 26,830
California and Alaska	14,913	386,664	24,905	22,240	201,614	7,028	91,175	35,771	3,931	361,759
Colorado	2,994	104,116	4,114	2,787	5,148	240	91,938	--	−111	100,002
Florida, Pennsylvania, West Virginia	8,118	326,092	11,625	4,119	22	--	309,466	797	63	314,467
Illinois and Kentucky	12,707	376,310	19,409	2,716	--	--	351,114	2,933	138	356,901
Kansas	30,604	1,497,319	40,738	9,268	1,884	82	1,374,268	71,362	−283	1,456,581
Louisiana	151,075	6,337,328	197,967	106,614	123,331	3,022	5,190,052	719,411	−3,069	6,139,361
Michigan	1,228	r 43,810	1,912	1,624	811	113	r 39,654	--	−304	r 41,898
Mississippi and Alabama	829	29,538	1,301	1,426	4,837	--	21,116	826	32	28,237
Montana and Utah	2,841	61,757	4,221	4,371	19,867	1,076	31,718	--	504	57,536
Nebraska and North Dakota	2,429	35,021	3,738	4,174	6,849	83	19,905	85	187	31,283
New Mexico	38,197	1,126,192	54,157	53,218	5,528	2,714	856,568	146,671	7,336	1,072,035
Oklahoma	41,707	1,116,872	56,376	45,604	76,872	207	842,165	92,869	2,779	1,060,496
Texas	319,061	8,139,408	470,105	317,136	931,461	9,825	5,566,168	811,374	33,339	7,669,303
Wyoming	10,706	298,439	16,228	9,692	13,636	566	248,432	9,407	478	282,211
Total	638,216	r 19,906,893	907,993	588,045	1,392,101	24,970	r 15,053,996	1,894,768	45,020	r 18,998,900
1973										
Arkansas	653	26,135	1,118	2,513	194	8	20,030	2,618	−346	25,017
California and Alaska	12,906	359,841	18,484	21,410	204,859	946	73,907	40,326	−91	341,357
Colorado	3,402	110,662	4,674	3,107	4,145	109	98,747	--	−120	105,988
Florida, Pennsylvania, West Virginia	8,554	375,090	12,385	4,391	11	--	357,722	581	--	362,705
Illinois and Kentucky	12,473	358,142	18,975	2,793	--	--	333,518	2,681	175	339,167
Kansas	30,456	1,503,660	43,909	9,746	1,678	65	1,366,017	82,363	−118	1,459,751
Louisiana	150,607	6,524,729	206,833	108,812	130,323	2,863	5,213,818	866,070	−3,990	6,317,896
Michigan	1,063	37,384	1,581	1,295	1,778	61	32,743	--	−74	35,803
Mississippi and Alabama	717	29,081	1,077	1,590	3,605	--	20,746	1,991	72	28,004
Montana and Utah	3,111	56,960	4,407	4,328	18,847	873	27,913	--	592	52,553
Nebraska and North Dakota	2,246	33,369	3,443	3,305	6,266	87	19,858	--	410	29,926
New Mexico	39,500	1,101,341	55,782	48,582	4,764	3,178	860,313	122,409	6,313	1,045,559
Oklahoma	43,718	1,175,548	61,647	49,710	77,372	1,078	897,361	84,793	3,587	1,113,901
Texas	314,429	7,683,830	466,143	299,738	823,369	7,671	5,279,049	748,629	59,231	7,217,687
Wyoming	10,588	303,519	16,093	10,386	10,946	576	257,539	8,722	−743	287,426
Total	634,423	19,679,291	916,551	571,706	1,288,157	17,515	14,859,281	1,961,183	64,898	18,762,740

r Revised.

Table 10.—Comparison of actual firm requirements and firm curtailments for year April 1973 through March 1974 with projections for year April 1974 through March 1975

(Million cubic feet)

	Total for year April 1973-March 1974			Total for year April 1974-March 1975		
	Actual			Projected		
	Firm requirements	Volume curtailed	Percent curtailed	Firm requirements	Deficiency	Percent Deficient
Alabama-Tennessee Natural Gas Co	26,540	--	--	31,678	--	--
Algonquin Gas Transmission Co	153,746	9,882	6.42	166,956	12,454	7.46
Arkansas Louisiana Gas Co	556,958	164,200	29.48	547,725	175,092	31.96
Cities Service Gas Co	557,176	38,610	6.92	583,192	95,203	16.32
Colorado Interstate Gas Co	389,174	--	--	370,738	--	--
Columbia Gas Transmission Corp.[1]	1,357,586	--	--	1,465,366	84,253	5.74
Consolidated Gas Supply Corp.[2]	700,691	--	--	776,782	7,965	1.02
East Tennessee Natural Gas Corp	98,826	--	--	109,106	--	--
Eastern Shore Natural Gas Co	11,153	42	.38	10,848	--	--
El Paso Natural Gas Co.[3]	1,801,829	113,109	6.27	1,461,897	248,268	16.98
Florida Gas Transmission Co	28,090	--	--	39,288	--	--
Great Lakes Gas Transmission Co	424,844	--	--	419,066	--	--
Kansas-Nebraska Natural Gas Co	82,828	--	--	81,153	--	--
Kentucky-West Virginia Gas Co	23,238	--	--	25,292	--	--
Lawrenceburg Gas Transmission Corp	5,322	--	--	5,419	--	--
Louisiana-Nevada Transit Co	4,846	107	2.20	4,873	705	14.46
McCulloch Interstate Gas Corp	17,740	--	--	14,319	--	--
Michigan Wisconsin Pipe Line Co	922,267	--	--	939,514	--	--
Mid Louisiana Gas Co	32,042	--	--	33,752	--	--
Midwestern Gas Transmission Co	349,004	--	--	351,056	--	--
Mississippi River Transmission Corp	203,916	2,601	1.28	222,582	--	--
Montana-Dakota Utilities Co	35,669	--	--	38,242	--	--
Natural Gas Pipeline Co. of America	1,193,911	221,823	18.58	1,200,971	208,792	17.38
North Penn Gas Co	28,084	--	--	29,818	--	--
Northern Natural Gas Co	884,834	9,446	1.06	834,795	6,375	.76
Northwest Pipeline Corp.[3]	84,468	10,807	12.79	428,922	37,758	8.80
Pacific Gas Transmission Co	423,279	--	--	415,845	--	--
Panhandle Eastern Pipe Line Co	827,568	37,514	4.53	817,162	70,791	8.66
South Georgia Natural Gas Co	10,694	--	--	10,908	--	--
Southern Natural Gas Co	597,284	53	.01	631,733	--	--
Tennessee Gas Pipeline Co., a division of Tenneco, Inc	1,353,094	--	--	1,383,990	--	--
Tennessee Natural Gas Lines, Inc	34,725	--	--	24,817	--	--
Texas Eastern Transmission Corp	1,069,704	133,212	12.45	1,098,682	204,022	18.56
Texas Gas Pipe Line Corp	4,747	--	--	2,432	--	--
Texas Gas Transmission Corp	742,677	--	--	737,118	34,123	4.62
Transcontinental Gas Pipe Line Corp	1,085,833	160,557	14.78	1,103,725	246,497	22.33
Transwestern Pipeline Co	358,355	5,116	1.42	366,290	63,653	17.38
Trunkline Gas Co	587,077	157,019	26.74	592,855	204,344	34.46
United Gas Pipe Line Co	1,565,442	506.682	32.36	1,608,438	658,738	40.96
United Natural Gas Co	97,259	--	--	101,971	--	--
West Texas Gathering Co	96,666	--	--	90,114	--	--
Western Gas Interstate Co	7,613	--	--	8,421	--	--
Total	18,836,799	1,570,780	8.34	19,187,851	2,359,033	12.29
Less pipeline to pipeline curtailments	XX	379,446	XX	XX	513,263	XX
Net curtailments	XX	1,191,334	XX	XX	1,845,770	XX

XX Not applicable.

[1] Columbia Gas Transmission Corp. states that during the period November 1973 through March 1974 a 2% curtailment was imposed on all CD, WS and G customers; however, due to warmer than normal weather, energy conservation, etc., actual curtailment cannot be ascertained.

[2] Consolidated Gas Supply Corp. data is on an "as measured" basis.

[3] On Jan. 31, 1974, El Paso divested its Northwest Division System properties to Northwest Pipeline Corp. Northwest has filed actual data for February and March 1974, as well as projected data for the period Apr. 1, 1974, through Mar. 31, 1975.

Source: Federal Power Commission.

Table 11.—Comparison of actual interruptible sales and curtailments for year April 1973 through March 1974 with projected requirements and deficiencies for year April 1974 through March 1975

(Million cubic feet)

	Actual-year April 1973-March 1974			Projected-year April 1974-March 1975		
	Interruptible requirement	Volume curtailed	Percent curtailed	Interruptible requirement	Volume deficient	Percent deficiency
Alabama-Tennessee Natural Gas Co	15,349	3,467	22.59	16,069	4,903	30.51
Algonquin Gas Transmission Co	10,652	10,652	100.00	12,366	12,366	100.00
Arkansas Louisiana Gas Co	6,525	6,525	100.00	19,533	19,533	100.00
Colorado Interstate Gas Co	26,994	--	--	37,910	10,447	27.56
East Tennessee Natural Gas Corp	23,683	--	--	26,154	--	--
Eastern Shore Natural Gas Co	1,792	1,241	69.25	2,284	2,006	87.83
El Paso Natural Gas Co.[1]	44,301	33,861	76.43	--	--	--
Florida Gas Transmission Co	129,031	28,908	22.40	142,741	66,649	46.69
Kansas-Nebraska Natural Gas Co	33,034	--	--	29,657	--	--
Louisiana-Nevada Transit Co	1,989	17	.85	5,585	2,174	38.93
Mississippi River Transmission Corp	35,292	29,304	83.03	35,285	35,285	100.00
Montana-Dakota Utilities Co	20,970	256	1.22	21,742	330	1.52
Northern Natural Gas Co	3,777	--	--	16,247	--	--
Northwest Pipeline Corp.[1]	4,155	4,155	100.00	11,902	9,484	79.68
Panhandle Eastern Pipe Line Co	73,725	12,057	16.35	72,129	20,959	29.06
South Georgia Natural Gas Co	16,499	8,357	50.65	16,285	8,357	51.32
Southern Natural Gas Co	168,041	97,023	57.74	135,325	97,729	72.22
Tennessee Natural Gas Lines, Inc	15,479	1,909	12.33	15,949	4,415	27.68
Texas Gas Transmission Corp	4,020	--	--	4,080	3,107	76.15
Transwestern Pipeline Co	1,038	--	--	1,029	--	--
Total	636,346	237,732	37.36	622,272	297,744	47.85
Less pipeline to pipeline curtailments	XX	29,420	XX	XX	46,380	XX
Net curtailments	XX	208,312	XX	XX	251,364	XX

XX Not applicable.

[1] On Jan. 31, 1974, El Paso divested its Northwest Division System properties to Northwest Pipeline Corp. Northwest has filed actual data for February and March 1974, as well as projected data for the period Apr. 1, 1974, through Mar. 31, 1975.

Source: Federal Power Commission.

Table 12.—Marketed production, interstate shipments, and total consumption of natural gas in the United States, 1973

(Million cubic feet)

State and region	Marketed production	Interstate movements			Change in underground storage	Transmission loss and unaccounted for	Consumption
		Receipts	Deliveries	Net receipts (+) or deliveries (—)			
New England:							
Connecticut	--	151,382	87,523	63,859	242	1,008	62,609
Maine, New Hampshire, Vermont	--	14,275	--	14,275	--	394	13,881
Massachusetts	--	181,232	23,211	158,021	—2,468	4,942	155,547
Rhode Island	--	92,655	71,889	20,766	6	201	20,559
Total	--	439,544	182,623	256,921	—2,220	6,545	252,596
Middle Atlantic:							
New Jersey	--	779,068	474,736	304,332	404	2,362	301,566
New York	4,539	944,949	249,573	695,376	1,160	16,208	682,547
Pennsylvania	78,514	2,048,053	1,276,144	771,909	44,570	22,485	783,368
Total	83,053	3,772,070	2,000,453	1,771,617	46,134	41,055	1,767,481
East North Central:							
Illinois	1,638	2,329,907	1,085,154	1,244,753	74,522	8,069	1,163,800
Indiana	276	2,047,305	1,487,347	559,958	14,151	3,783	542,300
Michigan	44,579	925,952	14,736	911,216	31,695	2,168	921,932
Ohio	93,610	2,978,272	1,929,823	1,048,449	25,411	12,492	1,104,156
Wisconsin	--	439,371	81,686	357,685	166	—10,442	367,961
Total	140,103	8,720,807	4,598,746	4,122,061	145,945	16,070	4,100,149
West North Central:							
Iowa	--	1,323,459	937,517	385,942	16,659	4,643	364,640
Kansas	893,118	2,079,962	2,314,562	—234,600	9,652	497	648,369
Minnesota	--	604,262	246,767	357,495	531	—3,847	360,811
Missouri	33	1,644,311	1,210,425	433,886	1,117	5,995	426,807
Nebraska	3,836	1,361,501	1,133,627	227,874	3,152	—1,548	230,106
North Dakota	27,703	11,058	4,308	6,750	--	—944	35,397
South Dakota	--	62,663	31,089	31,574	--	353	31,221
Total	924,690	7,087,216	5,878,295	1,208,921	31,111	5,149	2,097,351
South Atlantic:							
Delaware	--	25,456	1,996	23,460	255	256	22,949
Florida	33,857	282,070	--	282,070	--	1,543	314,384
Georgia	--	1,388,683	1,044,611	344,072		—4,017	348,089
Maryland and District of Columbia	298	862,879	657,919	204,960	—901	4,198	201,961
North Carolina	--	871,572	710,868	160,704	97	—264	160,871
South Carolina	--	1,022,225	871,572	150,653	6	—2,500	153,147
Virginia	5,101	1,008,381	854,454	153,927	183	5,997	152,848
West Virginia	208,676	1,543,718	1,515,862	27,856	23,510	17,278	195,744
Total	247,932	7,004,984	5,657,282	1,347,702	23,150	22,491	1,549,993

See footnotes at end of table.

Table 12.—Marketed production, interstate shipments, and total consumption of natural gas in the United States, 1973—Continued

(Million cubic feet)

State and region	Marketed production	Interstate movements: Receipts	Interstate movements: Deliveries	Interstate movements: Net receipts (+) or deliveries (−)	Change in underground storage	Transmission loss and unaccounted for	Consumption
East South Central:							
Alabama	11,271	3,157,465	2,898,432	259,033	554	−2,517	272,267
Kentucky	62,396	4,193,000	3,979,588	213,412	16,245	8,650	250,913
Mississippi	99,706	6,636,027	6,420,802	215,225	6,488	−6,427	314,870
Tennessee	20	4,503,040	4,202,057	300,983	1,580	5,803	293,620
Total	173,393	18,489,532	17,500,879	988,653	24,867	5,509	1,131,670
West South Central:							
Arkansas	157,529	2,701,399	2,519,599	181,800	586	9,822	328,921
Louisiana	8,242,423	1,256,830	7,162,687	−5,905,857	84,911	34,963	2,216,692
Oklahoma	1,770,980	1,268,128	2,333,024	−1,064,896	22,202	10,497	673,385
Texas	8,513,850	551,332	3,941,863	−3,390,531	1,404	34,394	5,087,521
Total	18,684,782	5,777,689	15,957,173	−10,179,484	109,103	89,676	8,306,519
Mountain:							
Arizona	125	1,533,942	1,318,062	215,880	--	1,682	214,323
Colorado	137,725	328,439	126,573	201,866	5,290	5,620	328,681
Idaho	--	524,831	469,131	55,700	--	−345	56,045
Montana	56,175	84,791	46,280	38,511	4,565	−1,027	91,148
Nevada	--	74,358	--	74,358	--	1,286	73,072
New Mexico	1,218,749	844,003	1,740,552	−896,549	3,043	6,564	312,593
Utah	42,715	234,442	147,833	86,609	1,627	1,102	126,595
Wyoming	357,731	96,638	332,248	−235,610	2,640	−5,211	124,692
Total	1,813,220	3,721,444	4,180,679	−459,235	17,165	9,671	1,327,149
Pacific:							
Alaska	131,007	--	48,346	−48,346	16,327	2,275	64,059
California	449,369	1,636,723	--	1,636,723	26,815	−3,848	2,063,125
Oregon	--	490,611	382,264	108,347	189	197	107,961
Washington	--	704,325	502,473	201,852	2,918	1,073	197,861
Total	580,376	2,831,659	933,083	1,898,576	46,249	−303	2,433,006
Total United States	22,647,549	[1] 57,844,945	[2] 56,889,213	955,732	441,504	195,863	22,965,914

[1] Includes receipts from Canada of 437,857 MMcf into Idaho; 267,401 MMcf into Washington; 262,434 MMcf into Minnesota; 50,064 MMcf into Montana; 5,546 MMcf into New York; 3,912 MMcf into Vermont; and from Mexico 1,632 MMcf into Texas; and liquefied natural gas (gaseous equivalent) imports into Massachusetts of 3,388 MMcf from Algeria and 667 MMcf from Canada.

[2] Includes deliveries to Canada of 14,736 MMcf from Michigan; 88 MMcf from Montana and into Mexico; 9,522 MMcf from Texas; 4,477 MMcf from Arizona; and liquefied natural gas exports of 48,346 MMcf to Japan from Alaska.

Table 13.—Interstate pipeline movements of natural gas in the United States

(Billion cubic feet at 14.73 psia)

State and region	Net receipts from: Within region: State	Quantity	Outside region: State	Quantity	Net deliveries to: Within region: State	Quantity	Outside region: State	Quantity	Net receipts and deliveries (—) [1]
New England:									
Connecticut	Massachusetts	7.7	New York	143.7	Rhode Island	87.5	--	--	63.9
Maine, New Hampshire, Vermont	Massachusetts	10.4	Canada	3.9	--	--	--	--	14.3
Massachusetts	Rhode Island	66.8	New York	105.3	Connecticut	7.7	--	--	158.0
	--	--	Canada	[1].7	New Hampshire	10.4	--	--	--
	--	--	Algeria	[1]3.4	--	--	--	--	--
Rhode Island	Connecticut	87.5	--	--	Massachusetts	66.8	--	--	20.7
Total	--	172.4	--	257.0	--	172.4	--	--	256.9
Middle Atlantic:									
New Jersey	Pennsylvania	778.6	--	--	New York	474.3	--	--	304.3
New York	New Jersey	474.3	Canada	5.5	--	--	Connecticut	143.7	695.4
	Pennsylvania	464.5	--	--	--	--	Massachusetts	105.3	--
Pennsylvania	--	--	Maryland	655.2	New Jersey	778.6	Delaware	25.5	771.9
	--	--	West Virginia	820.7	New York	464.5	--	--	--
	--	--	Ohio	564.6	--	--	--	--	--
Total	--	1,717.4	--	2,046.0	--	1,717.4	--	274.5	1,771.6
East North Central:									
Illinois	--	--	Iowa	602.7	Indiana	673.5	--	--	1,244.8
	--	--	Kentucky	495.1	Wisconsin	198.0	--	--	--
	--	--	Missouri	1,018.4	--	--	--	--	--
Indiana	Illinois	673.5	Kentucky	1,160.2	Ohio	1,273.7	--	--	560.0
Michigan	Ohio	844.3	--	--	--	--	Canada	14.7	911.2
	Wisconsin	81.7	--	--	--	--	--	--	--
Ohio	Indiana	1,273.7	Kentucky	1,315.0	Michigan	844.3	Pennsylvania	564.6	1,048.4
	--	--	--	--	--	--	West Virginia	131.4	--
Wisconsin	Illinois	198.0	Minnesota	241.4	Michigan	81.7	--	--	357.7
Total	--	3,071.2	--	4,832.8	--	3,071.2	--	710.7	4,122.1
West North Central:									
Iowa	Missouri	192.0	--	--	Minnesota	323.3	Illinois	602.7	385.9
	South Dakota	.3	--	--	--	--	--	--	--
	Nebraska	1,119.6	--	--	--	--	--	--	--
Kansas	--	--	Oklahoma	2,057.4	Missouri	929.9	Colorado	51.7	—234.6
	--	--	--	--	Nebraska	1,310.4	--	--	--
Minnesota	Iowa	323.3	Canada	262.4	North Dakota	5.4	Wisconsin	241.4	357.5
	South Dakota	18.5	--	--	--	--	--	--	--
Missouri	Kansas	929.9	Arkansas	714.3	Iowa	192.0	Illinois	1,018.4	433.9
	--	--	Oklahoma	.1	--	--	--	--	--
Nebraska	Kansas	1,310.4	Colorado	2.2	Iowa	1,119.6	--	--	227.9
	--	--	Wyoming	45.6	South Dakota	10.6	--	--	--
North Dakota	Minnesota	5.4	Montana	1.3	--	--	--	--	6.7
South Dakota	Nebraska	10.6	Montana	40.5	Iowa	.3	Wyoming	.6	31.6
	--	--	--	--	Minnesota	18.5	--	--	--
Total	--	3,910.0	--	3,123.8	--	3,910.0	--	1,914.8	2,208.9

Table 13.—Interstate pipeline movements of natural gas in the United States—Continued

(Billion cubic feet at 14.73 psia)

State and region	Net receipts from				Net deliveries to				Net receipts and deliveries (—) [1]
	Within region		Outside region		Within region		Outside region		
	State	Quantity	State	Quantity	State	Quantity	State	Quantity	
South Atlantic:									
Delaware	--	--	Pennsylvania	25.5	Maryland	2.0	--	--	23.5
Florida	Georgia	7.1	Alabama	274.9	--	--	--	--	282.1
Georgia	--	--	Alabama	1,388.7	Florida	7.1	Tennessee	15.3	344.1
	--	--	--	--	South Carolina	1,022.2	--	--	--
Maryland and District of Columbia	Delaware	2.0	--	--	--	--	Pennsylvania	655.2	205.0
	West Virginia	10.4	--	--	--	--	--	--	--
	Virginia	847.7	--	--	--	--	--	--	--
North Carolina	South Carolina	871.6	--	--	Virginia	710.9	--	--	160.7
South Carolina	Georgia	1,022.2	--	--	North Carolina	871.6	--	--	150.6
Virginia	North Carolina	710.9	Tennessee	9.1	District of Columbia	14.0	--	--	153.9
	West Virginia	281.7	--	--	Maryland	833.7	--	--	--
West Virginia	--	--	Kentucky	1,009.4	Maryland	10.4	Pennsylvania	820.7	27.8
	--	--	Ohio	131.4	Virginia	281.7	--	--	--
Total	--	3,753.6	--	2,839.0	--	3,753.6	--	1,491.2	1,347.7
East South Central:									
Alabama	Mississippi	3,147.9	--	--	Tennessee	1,225.2	Florida	274.9	259.0
	--	--	--	--	--	--	Georgia	1,388.7	--
Kentucky	Tennessee	4,193.0	--	--	--	--	Illinois	495.1	213.4
	--	--	--	--	--	--	Indiana	1,160.2	--
	--	--	--	--	--	--	West Virginia	1,009.4	--
	--	--	--	--	--	--	Ohio	1,315.0	--
Mississippi	--	--	Arkansas	1,797.9	Alabama	3,147.9	Virginia	9.1	215.2
	--	--	Louisiana	4,827.8	Tennessee	3,262.5	--	--	--
Tennessee	Alabama	1,225.2	Georgia	15.3	Kentucky	4,193.0	--	--	301.0
	Mississippi	3,262.5	--	--	--	--	--	--	--
Total	--	11,828.6	--	6,641.0	--	11,828.6	--	5,652.4	988.6
West South Central:									
Arkansas	Louisiana	1,997.8	--	--	--	--	Mississippi	1,797.9	181.8
	Oklahoma	110.9	--	--	--	--	Missouri	714.3	--
	Texas	585.3	--	--	--	--	--	--	--
Louisiana	Texas	919.7	--	--	Arkansas	1,997.8	Mississippi	4,827.8	—5,905.8
Oklahoma	Texas	1,194.7	--	--	Arkansas	110.9	Colorado	91.2	—1,065.0
	--	--	--	--	--	--	Missouri	.1	--
	--	--	--	--	--	--	Kansas	2,057.4	--
Texas	--	--	--	--	Arkansas	585.3	New Mexico	683.0	—3,390.5
	--	--	--	--	Louisiana	919.7	Mexico	7.9	--
	--	--	--	--	Oklahoma	1,194.7	--	--	--
Total	--	4,808.4	--	--	--	4,808.4	--	10,179.6	—10,179.5

Mountain:									
Arizona	New Mexico	1,526.8	--	--	Nevada	40.8	California	1,269.2	215.9
	Utah	3.6	--	--	--	--	Mexico	4.5	--
Colorado	New Mexico	52.7	Kansas	51.7	Utah	107.6	Nebraska	2.2	201.9
	Wyoming	116.0	Oklahoma	91.2	--	--	--	--	--
Idaho	Utah	61.7	Oregon	13.4	Nevada	33.5	Washington	423.7	55.7
	--	--	Canada	437.9	--	--	--	--	--
Montana	Wyoming	30.3	Canada	50.0	--	--	South Dakota	40.5	38.5
	--	--	--	--	--	--	North Dakota	1.3	--
Nevada	Idaho	33.5	--	--	--	--	--	--	74.3
	Arizona	40.8	--	--	--	--	--	--	--
New Mexico	--	--	Texas	683.0	Arizona	1,526.8	--	--	—896.5
	--	--	--	--	Colorado	52.7	--	--	--
Utah	Colorado	107.6	--	--	Arizona	3.6	--	--	86.6
	Wyoming	44.3	--	--	Idaho	61.7	--	--	--
Wyoming	--	--	South Dakota	.6	Colorado	116.0	Nebraska	45.6	—235.6
	--	--	--	--	Montana	30.3	--	--	--
	--	--	--	--	Utah	44.3	--	--	--
Total	--	2,017.3	--	1,327.8	--	2,017.3	--	1,787.0	—459.2
Pacific:									
Alaska	--	--	--	--	--	--	Japan	[1] 48.3	—48.3
California	Oregon	367.5	Arizona	1,269.2	--	--	--	--	1,636.7
Oregon	Washington	489.3	--	--	California	367.5	Idaho	13.4	108.3
Washington	--	--	Canada	267.4	Oregon	437.9	--	--	201.9
	--	--	Idaho	423.7	--	--	--	--	--
Total	--	856.8	--	1,960.3	--	856.8	--	61.7	1,898.6
United States	--	--	Canada	1,013.1	--	--	Japan	[1] 48.3	955.7
	--	--	Algeria	[2] 3.4	--	--	Mexico	12.4	--
Total United States	--	--	--	1,016.5	--	--	--	60.7	955.7

[1] Data may not add to totals shown because of independent rounding.
[2] Liquefied natural gas.

Table 14.—Estimated total proved reserves of natural gas in the United States

(Million cubic feet at 14.73 psia at 60° F)

State	Reserves as of Dec. 31, 1972	Changes in reserves during 1973: Revisions	Extensions	New field discoveries	New reservoir discoveries in old fields	Net change in underground storage [1]	Production [2]	Reserves as of Dec. 31, 1973: Total gas	Non-associated	Associated-dissolved	Underground storage [3]
Alabama	245,714	−30,585	114,138	6,000	--	--	7,892	327,375	309,338	18,037	--
Alaska	31,455,443	71,398	246,000	600	--	--	130,815	31,642,626	5,210,166	26,432,460	--
Arkansas	2,455,877	−39,597	13,870	1,000	1,050	739	163,586	2,269,353	2,082,558	152,294	34,501
California [4]	5,328,862	50,488	192,094	99,000	11,850	−4,101	478,356	5,199,837	2,380,028	2,540,137	279,672
Colorado	1,655,200	47,889	269,512	26,358	1,556	2,060	134,276	1,868,299	1,592,362	250,904	25,033
Florida	180,629	−2,262	4,207	--	--	--	33,660	148,914	--	148,914	--
Illinois	545,361	1,978	--	--	--	−163,974	2,840	380,525	1,103	24,195	355,227
Indiana	87,324	509	--	--	--	−19,787	1,364	66,682	2,178	3,789	60,715
Kansas	11,938,716	323,943	311,385	31,124	--	16,687	899,460	11,722,395	11,411,765	203,533	107,097
Kentucky	938,082	−2,265	19,869	2,051	1,559	−31,979	62,396	864,921	709,030	43,187	112,704
Louisiana [4]	74,971,334	−609,005	1,451,403	549,696	1,239,234	6,547	8,457,596	69,151,613	57,239,668	11,732,832	179,113
Michigan	1,296,815	17,637	23,660	250,938	--	7,300	47,842	1,548,508	492,825	431,086	624,597
Mississippi	1,104,336	123,374	20,281	36,691	1,741	−11,548	96,657	1,178,218	968,414	120,711	89,093
Montana	1,064,036	8,122	29,224	16,861	29,852	4,563	60,209	1,092,449	821,513	85,625	185,311
Nebraska	50,260	2,022	525	17	--	438	4,446	48,816	13,779	8,795	26,242
New Mexico	12,335,647	698,650	556,057	61,751	14,663	16,301	1,194,706	12,488,363	9,814,816	2,657,246	16,301
New York	139,184	--	4,725	--	--	−2,784	4,283	136,842	31,972	70	104,800
North Dakota	441,625	−10,658	54,306	10	--	--	37,099	448,184	6,372	441,812	--
Ohio	1,146,677	−4,903	168,378	19,544	--	−60,778	89,527	1,179,391	649,260	159,383	370,748
Oklahoma	14,492,030	534,587	704,569	127,942	7,390	10,004	1,777,787	14,098,735	11,183,035	2,675,836	239,864
Pennsylvania	1,406,948	--	153,275	12,100	2,000	−1,428	78,514	1,494,381	876,818	12,050	605,513
Texas [4]	95,042,043	−4,713,311	1,503,765	746,018	599,637	−1,172	8,240,478	84,936,502	60,530,423	24,268,979	137,100
Utah	1,022,110	−26,556	67,710	12,505	--	−17	51,029	1,024,723	541,376	481,697	1,650
Virginia	35,921	--	6,300	100	--	--	5,048	37,273	37,273	--	--
West Virginia	2,345,957	−256	148,710	8,478	5,371	−20,409	168,023	2,319,828	1,912,318	52,319	355,191
Wyoming	4,088,728	87,240	113,023	142,843	54,065	382	376,758	4,109,523	3,413,115	641,032	55,376
Other States [5]	269,987	−3,195	300	524	400	−101,326	759	165,931	14,433	837	150,661
Total United States	266,084,846	−3,474,756	6,177,286	2,152,151	1,970,368	−354,282	22,605,406	249,950,207	172,245,938	73,587,760	4,116,509

[1] The net difference between gas stored in and gas withdrawn from underground storage reservoirs inclusive of adjustments and native gas transferred from other reserve categories. (Adjustments include change of reporting basis to report only gas reserves considered recoverable with a net result of a 781,819 MMcf reduction.)

[2] Preliminary net production.

[3] Gas held in underground reservoirs (including native and net injected gas) for storage purposes.

[4] Includes offshore reserves.

[5] Includes Arizona, Iowa, Maryland, Minnesota, Missouri, South Dakota, Tennessee, and Washington.

Source: Committee on Natural Gas Reserves. American Gas Association.

Table 15.—Estimated daily productive capacity of natural gas in the United States[1]

(Million cubic feet per day at 14.73 psia at 60° F)

State	Productive capacity: Non-associated	Productive capacity: Associated-dissolved	Productive capacity: Total	State	Productive capacity: Non-associated	Productive capacity: Associated-dissolved	Productive capacity: Total
Alabama	47	12	59	New Mexico	2,579	1,094	3,673
Alaska	549	72	621	New York	12	--	12
Arkansas	688	37	725	North Dakota	1	123	124
California [2]	1,086	744	1,830	Ohio	253	32	285
Colorado	441	71	512	Oklahoma	6,928	1,720	8,648
Florida	--	93	93	Pennsylvania	220	3	223
Illinois	1	7	8	Texas [2]	21,726	5,919	27,645
Indiana	--	3	3	Utah	120	84	204
Kansas	4,047	182	4,229	Virginia	27	--	27
Kentucky	215	10	225	West Virginia	505	5	510
Louisiana [2]	23,072	3,258	26,330	Wyoming	844	370	1,214
Michigan	346	131	477	Other States [3]	2	--	2
Mississippi	235	60	295	Total	64,160	14,071	78,231
Montana	209	35	244				
Nebraska	7	6	13				

[1] During the heating season immediately following Dec. 31, 1973.
[2] Includes offshore productive capacity.
[3] Includes Arizona, Iowa, Maryland, Minnesota, Missouri, South Dakota, Tennessee, and Washington.

Source: Committee on Natural Gas Reserves, American Gas Association.

Table 16.—Underground storage statistics, December 31, 1973

(Million cubic feet at 14.73 psia at 60° F)

State	Number of reservoirs	Type of reservoir: Dry gas	Type of reservoir: Oil and gas	Type of reservoir: Oil	Type of reservoir: Water	Type of reservoir: Other	Number of wells	Total stored gas in underground reservoirs (million cubic feet)	Total reservoir capacity (million cubic feet)
Arkansas	5	5	--	--	--	--	22	10,829	42,540
California	7	3	4	--	--	--	289	156,196	381,459
Colorado	6	4	1	--	--	[1] 1	63	18,641	30,007
Illinois	29	8	--	1	20	--	1,478	571,314	951,933
Indiana	28	17	--	--	11	--	889	72,981	159,914
Iowa	7	--	--	--	7	--	318	163,320	328,800
Kansas	17	17	--	--	--	--	749	83,594	116,333
Kentucky	21	15	2	--	4	--	1,117	83,231	203,376
Louisiana	6	6	--	--	--	--	119	174,162	239,488
Maryland	1	1	--	--	--	--	66	27,983	64,770
Michigan	36	32	1	1	--	[2] 2	2,547	430,779	801,127
Minnesota	1	--	--	--	1	--	45	4,475	20,000
Mississippi	4	3	--	--	--	[2] 1	69	78,442	109,517
Missouri	1	--	--	--	1	--	73	27,997	45,000
Montana	5	5	--	--	--	--	134	139,173	213,152
Nebraska	1	1	--	--	--	--	15	17,873	39,270
New Mexico	2	1	--	--	1	--	42	6,792	53,876
New York	18	18	--	--	--	--	738	101,654	141,728
Ohio	22	22	--	--	--	--	3,063	373,114	505,389
Oklahoma	11	10	1	--	--	--	192	225,127	317,451
Pennsylvania	68	68	--	--	--	--	2,141	614,076	783,450
Texas	17	6	5	6	--	--	181	91,463	186,464
Utah	1	--	--	--	1	--	8	1,777	1,783
Washington	2	--	--	--	2	--	61	19,364	20,048
West Virginia	35	34	1	--	--	--	1,163	369,031	435,893
Wyoming	9	8	--	--	1	--	25	42,844	86,002
Total	360	284	15	8	49	4	15,607	3,906,232	6,278,770

[1] Coal.
[2] Salt.

Source: American Gas Association.

Table 17.—Natural gas stored in and withdrawal statistics

(Million cubic feet at 14.73 psia)

State	1972			1973		
	Total stored	Total withdrawn	Net stored	Total stored	Total withdrawn	Net stored
Alabama	568	439	129	1,070	516	554
Alaska	--	--	--	16,327	--	16,327
Arkansas	1,316	1,187	129	2,218	1,632	586
California	118,758	73,087	45,671	92,331	65,516	26,815
Colorado	8,502	9,024	−522	10,673	5,383	5,290
Connecticut	--	--	--	683	441	242
Delaware	--	--	--	255	--	255
Illinois	237,098	197,188	39,910	233,112	158,590	74,522
Indiana	40,220	40,296	−76	46,617	32,466	14,151
Iowa	53,137	45,858	7,279	57,011	40,352	16,659
Kansas	46,810	48,391	−1,581	42,910	33,258	9,652
Kentucky	51,437	43,138	8,299	54,392	38,147	16,245
Louisiana	84,201	84,734	−533	151,287	66,376	84,911
Maryland	7,920	8,192	−272	11,328	12,229	−901
Massachusetts	1,496	422	1,074	413	2,881	−2,468
Michigan	275,460	306,491	−31,031	299,766	268,071	31,695
Minnesota	--	--	--	829	298	531
Mississippi	83,548	7,944	75,604	29,089	22,601	6,488
Missouri	10,188	8,692	1,496	10,847	9,730	1,117
Montana	8,801	7,281	1,520	16,969	12,404	4,565
Nebraska	8,837	2,282	6,555	5,280	2,128	3,152
New Jersey	1,765	1,785	−20	1,867	1,463	404
New Mexico	--	--	--	5,067	2,024	3,043
New York	32,777	42,894	−10,117	40,277	39,117	1,160
North Carolina	--	--	--	97	--	97
Ohio	163,884	185,454	−21,570	179,078	153,667	25,411
Oklahoma	59,061	66,852	−7,791	88,000	65,798	22,202
Oregon	--	--	--	189	--	189
Pennsylvania	315,183	322,254	−7,071	321,757	277,187	44,570
Rhode Island	--	--	--	97	91	6
South Carolina	--	--	--	48	42	6
Tennessee	--	--	--	1,606	26	1,580
Texas	87,251	47,269	39,982	46,592	45,188	1,404
Utah	906	691	215	2,320	693	1,627
Virginia	278	93	185	320	137	183
Washington	9,608	6,365	3,243	8,598	5,680	2,918
West Virginia	171,946	194,109	−22,163	184,984	161,474	23,510
Wisconsin	--	--	--	166	--	166
Wyoming	11,996	4,806	7,190	9,854	7,214	2,640
Total	1,892,952	1,757,218	135,734	1,974,324	1,532,820	441,504

Table 18.—Quantity and value of marketed production of natural gas in the United States

State	1972 Quantity (million cubic feet) [1]	1972 Value (thousand dollars)	1972 Average wellhead value (cents per thousand cubic feet)	1973 Quantity (million cubic feet) [1]	1973 Value (thousand dollars)	1973 Average wellhead value (cents per thousand cubic feet)
Alabama	3,644	1,282	35.2	11,271	4,307	38.2
Alaska	125,596	18,463	14.7	131,007	19,483	14.9
Arizona	442	80	18.1	125	23	18.4
Arkansas	166,522	28,808	17.3	157,529	28,985	18.4
California	487,278	179,318	36.8	449,369	167,615	37.3
Colorado	116,949	1,930	16.5	137,725	24,304	17.7
Florida	15,521	4,967	32.0	33,857	11,613	34.3
Illinois	1,194	334	28.0	1,638	573	35.0
Indiana	355	55	15.5	276	38	13.8
Kansas	889,268	127,859	14.4	893,118	138,521	15.5
Kentucky	63,648	15,976	25.1	62,396	21,839	35.0
Louisiana	7,972,678	1,626,426	20.4	8,242,423	1,846,303	22.4
Maryland	244	51	20.9	298	69	23.3
Michigan	34,221	10,506	30.7	44,579	17,495	39.2
Mississippi	103,989	r 22,670	r 21.8	99,706	22,846	22.9
Missouri	9	2	24.9	33	8	24.2
Montana	33,474	4,117	12.3	56,175	13,240	23.6
Nebraska	3,478	619	17.8	3,836	698	18.2
New Mexico	1,216,061	225,420	18.5	1,218,749	287,889	23.6
New York	3,679	1,199	32.6	4,539	1,590	35.0
North Dakota	32,472	5,455	16.8	27,703	5,457	19.7
Ohio	89,995	35,271	39.2	93,610	39,786	42.5
Oklahoma	1,806,887	294,523	16.3	1,770,980	334,110	18.9
Pennsylvania	73,958	22,389	30.3	78,514	32,976	42.0
Tennessee	25	8	30.0	20	6	30.0
Texas	8,657,840	1,419,886	16.4	8,513,850	1,735,221	20.4
Utah	39,474	6,711	17.0	42,715	8,159	19.1
Virginia	2,787	892	32.0	5,101	1,688	33.1
West Virginia	214,951	64,485	30.0	208,676	64,481	30.9
Wyoming	375,059	60,760	16.2	357,731	64,749	18.1
Total	22,531,698	r 4,180,462	18.6	22,647,549	4,894,072	21.6

r Revised.
[1] Marketed production of natural gas represents gross withdrawals less gas used for repressuring and quantities vented and flared.

Source: Figures based on reports received from State agencies and Bureau of Mines estimates.

Table 19.—Average wholesale prices for 14 large cities and adjacent areas [1]

(Cents per Mcf)

Standard metropolitan statistical area	July 1, 1965	July 1, 1967	July 1, 1969	July 1, 1970	July 1, 1971	July 1, 1972 [2]	July 1, 1973 [2]
Baltimore	45.85	42.32	41.98	43.98	52.60	53.22	54.51
Boston	58.32	60.37	68.64	65.76	76.17	76.73	83.61
Chicago [3]	33.59	30.03	29.63	31.93	36.04	36.65	44.76
Cleveland [3]	43.75	42.76	40.50	44.64	49.09	52.90	52.14
Detroit	38.69	37.11	38.82	39.91	41.48	47.34	51.21
Los Angeles [3 4]	31.85	31.24	31.60	34.63	38.78	40.74	42.25
Minneapolis-St. Paul	37.88	35.20	36.29	36.80	42.59	45.14	52.03
Newark (and New Jersey suburbs of New York) [3]	44.44	42.23	43.90	43.45	47.18	53.61	56.91
New York [3]	42.29	41.51	41.52	42.51	45.98	51.93	54.17
Philadelphia [3]	43.70	40.76	43.20	43.42	46.90	53.28	56.64
Pittsburgh [3]	39.30	38.85	38.37	43.44	49.78	49.26	48.24
St. Louis (Missouri portion only)	33.60	33.74	33.77	37.26	47.62	49.37	53.96
San Francisco-Oakland [3 4]	31.17	28.68	30.81	33.67	35.17	36.52	39.24
Washington, D.C. [3]	50.09	48.39	47.13	51.06	61.64	60.29	59.74

[1] The prices for July 1, 1965 through July 1, 1969 are from press releases issued by the FPC. The July 1, 1970, July 1, 1971 and Jan. 1, 1972 prices are based on 1970 sales volumes by pipelines to distributors (FPC Form 2). The prices for July 1, 1972 were based on 1971 sales volumes by pipelines to distributors, and the July 1, 1973 prices were based on 1972 sales volumes by pipelines to distributors (FPC Form 2).
[2] Reflects contingent rates in effect subject to subsequent reduction and refunds as of July 1, of year indicated.
[3] Wholesale service furnished by more than one pipeline company. Average prices are computed from the weighted average charges of all suppliers.
[4] Deliveries are not at city gates. Distributors must transport from State lines (California-Oregon and California-Arizona).

Source: Federal Power Commission.

Table 20.—Average price of residential heating gas by area 1966–1973

(Dollars per 10 therms)

Standard metropolitan statistical area	January 1966	January 1967	January 1968	January 1969	January 1970	January 1971	January 1972	January 1973	January 1974
Atlanta	0.824	0.824	0.824	0.824	0.824	0.824	1.009	1.107	1.117
Baltimore	1.189	1.284	1.225	1.265	1.332	1.327	1.513	1.513	1.564
Boston	1.420	1.416	1.426	1.436	1.499	1.568	1.802	1.814	2.103
Buffalo	.867	.878	.870	.905	.932	1.028	1.218	1.223	1.461
Chicago-Northwest Indiana	.926	.932	.944	.895	.965	1.021	1.110	1.130	1.207
Cincinnati	.764	.757	.771	.752	.799	.812	.943	.974	.992
Cleveland	.734	.736	.729	.732	.747	.858	.896	.938	.928
Dallas	.724	.727	.740	.755	.847	.849	.863	.890	.888
Detroit	.852	.850	.850	.850	.866	.873	.953	.998	1.155
Houston	.767	.767	.772	.871	.875	.928	.957	1.000	1.042
Kansas City	.582	.575	.569	.609	.681	.669	.717	.720	.771
Milwaukee	1.067	1.067	1.067	1.101	1.247	1.272	1.350	.391	1.446
Minneapolis-St. Paul	.860	.823	.810	.851	.877	.913	.998	1.073	1.119
New York-Northeast New Jersey	1.362	1.305	1.290	1.299	1.320	1.363	1.568	1.660	1.887
Philadelphia	1.370	1.380	1.379	1.380	1.381	1.430	1.459	1.531	1.714
Pittsburgh	.806	.796	.809	.845	.880	.970	1.018	1.064	1.144
St. Louis	.839	.839	.838	.842	.916	.979	1.093	1.097	1.173
San Francisco-Oakland	.599	.610	.608	.610	.622	.714	.762	.840	.920
Seattle	1.182	1.157	1.150	1.150	1.159	1.159	1.249	1.270	1.530
Washington, D.C	1.095	1.347	1.287	1.315	1.362	1.360	1.505	1.569	1.599
U.S. average	.835	.831	.838	.844	.874	.920	1.010	1.047	1.133

Source: Bureau of Labor Statistics, Monthly release, "Release Prices and Indexes of Fuels and Electricity" table 7; US. average, table 2.

Table 21.—Liquefied natural gas (LNG) exports, 1973

	Exports to Japan: Phillips Petroleum Co. from Port Nikiski, Alaska	Exports to Japan: Marathon Oil Co. from Port Nikiski, Alaska	Total Exports
Volume shipped:			
Barrels 42 U.S. gallons	9,731,938	4,203,005	13,934,943
Mcf equivalent @ 14.73 psia	33,716,918	14,629,438	48,346,356
Average Btu per cubic feet	1,015	1,015	1,015
Value:			
Total dollars	19,506,041	8,463,862	27,969,903
Average price cents per Mcf	57.85	57.86	57.86

Source: Federal Power Commission.

Table 22.—Natural gas exports via pipeline: Volume, value, and unit cost, 1972–1973

Exporting companies	Point of exit	Gas volume (thousand cubic feet at 14.73 psia and 60° F) 1972	Gas volume 1973	Percent change	Value (thousand dollars) 1972	Value 1973	Average price (cents per thousand cubic feet) 1972	Average price 1973
EXPORTS TO CANADA								
Interstate company:								
Panhandle Eastern Pipe Line Co	Detroit River-River Rouge, Mich	15,426,455	14,735,650	—4.5	7,746	8,090	50.21	54.91
Intrastate company:								
The Montana Power Co	Sweetgrass, Mont	126,223	87,822	—30.4	47	33	37.24	37.57
Total Canada [1]		15,552,678	14,823,472	—4.7	7,793	8,123	50.11	54.80
EXPORTS TO MEXICO								
Interstate company:								
El Paso Natural Gas Co	Naco, Ariz	4,521,863	4,477,062	—1.0	1,860	2,001	41.13	44.70
Intrastate companies:								
Del Norte Natural Gas Co	El Paso, Tex	2,719,557	3,770,477	38.6	1,300	1,916	47.81	50.82
Texas Gas Utilities Co	Eagle Pass, Tex	1,825,244	1,489,487	—18.4	608	589	33.31	39.54
Do	Laredo, Tex	4,281,604	3,011,513	—29.7	1,078	872	25.18	28.97
United Gas, Inc	do	1,230,715	1,250,722	1.6	323	427	26.25	34.14
Total intrastate		10,057,120	9,522,199	—5.3	3,309	3,804	32.90	39.96
Total Mexico		14,578,983	13,999,261	—4.0	5,169	5,805	35.45	41.48
Grand total exports		30,131,661	28,822,733	—4.3	12,962	13,928	43.02	48.33

[1] In addition Northern Natural Gas Co. delivered 28,600,169 Mcf produced from the Tiger Ridge Area, Montana, to Consolidated Natural Gas Co. at a point on the Montana-Sasketchewan border for transportation and received 28,337,785 Mcf into its line again on the Minnesota-Manitoba border, near Emerson, Manitoba.

Source: Federal Power Commission.

Table 23.—Natural gas imports via pipeline: Volume, value, and unit cost, 1972–73

Importing companies	Point of entry	Gas volume (thousand cubic feet at 14.73 psia and 60° F) 1972	Gas volume 1973	Percent change	Value (thousand dollars) 1972	Value 1973	Average price (cents per thousand cubic feet) 1972	Average price 1973
IMPORTS FROM CANADA								
Interstate companies:								
El Paso Natural Gas Co	Whatcom, Wash	255,495,902	267,400,874	4.7	83,210	96,367	32.57	36.04
Do	Eastport, Idaho	50,945,293	50,427,625	−2.0	16,511	17,881	32.40	35.46
Great Lakes Gas Transmission Co	Noyes, Minn	111,340,821	[1] 117,355,103	5.4	35,921	38,436	32.26	32.75
Inter-City Minnesota Pipeline Ltd.[2]	Warroad, Minn.[3]	8,098,257	[4] 7,898,143	−2.5	3,595	3,333	44.39	42.21
Michigan Wisconsin Pipeline Co	Noyes, Minn	18,300,000	18,250,000	−.3	6,142	6,232	33.56	34.15
Midwestern Gas Transmission Co	do	119,116,649	118,931,089	−.2	35,927	35,745	30.16	30.05
Pacific Gas Transmission Co	Eastport, Idaho	383,890,217	387,429,680	.9	110,352	138,524	28.75	35.75
Tennessee Gas Pipeline Co	Niagara Falls, N.Y	3,672,185	--	--	1,913	--	52.09	--
Total interstate		950,859,324	967,692,514	1.8	293,571	336,518	30.87	34.78
Intrastate companies:								
The Montana Power Co	Whitlash, Mont	16,390,602	19,349,636	18.1	3,905	5,377	23.82	27.79
Do	Babb, Mont	32,198,571	30,714,757	−4.6	7,383	10,084	22.93	32.83
St. Lawrence Gas Co., Inc	Massena, N.Y	5,898,854	5,546,469	−6.0	3,417	3,318	57.93	59.83
Vermont Gas Systems, Inc	Highgate Falls, Vt	3,745,406	3,912,384	4.5	2,245	2,453	59.95	62.70
Total intrastate		58,233,433	59,523,246	2.2	16,950	21,232	29.71	35.67
Total Canada		1,009,092,757	1,027,215,760	1.8	310,521	357,750	30.77	34.83
IMPORTS FROM MEXICO								
Interstate company:								
Texas Eastern Transmission Corp	McAllen, Tex	8,109,658	1,632,007	−79.9	1,340	271	16.52	16.62
Intrastate company:								
City of Roma, Texas	Roma, Tex	30,884	--	--	7	--	22.67	--
Total Mexico		8,140,542	1,632.007	−80.0	1,346	271	16.55	16.62
Grand total imports		1,017,233,299	1,028,847,767	1.1	311,868	358,021	30.66	34.80

[1] In addition to this amount 312,689,496 Mcf were received from Trans-Canada Pipe Line Ltd. for transportation and 313,689,496 Mcf were redelivered to Trans-Canada at St. Clair and Sault Ste. Marie, Mich.

[2] Inter-City Minnesota Pipelines Ltd. replaced ICG Transmission Ltd., which was listed as an interstate company, as holder of authorization in Docket No. CP70-289-Order 9/26/73.

[3] Second port of entry is International Falls, Minn.

[4] In addition to this amount 10,289,301 Mcf were received from Trans-Canada Pipe Line Ltd. for transportation and redelivery to Trans-Canada at Baudette, Minn.

Source: Federal Power Commission Form 14.

Table 24.—Liquefied natural gas (LNG) imports, 1973

	From Algeria			From Canada [1]				
	Boston Gas Co., received at Boston, Mass.	Distrigas Corp. received at Everett, Mass.	Total Algeria	Lowell Gas Co., received at Tewksbury, Mass.	Providence Gas Co., received at Exeter, R.I.	Brockton Taunton Gas, received at Easton, Mass.	Total Canada	Total imports
Volume received:								
Barrels 42 U.S. gallons	95,093	879,706	974,799	50,241	33,094	109,253	192,588	1,167,387
Mcf equivalent @ 14.73 psia	320,576	3,067,734	3,388,310	173,775	114,871	378,571	667,217	4,055,527
Average Btu per cubic feet	1,142	1,067	1,074	1,077	1,051	1,058	1,062	1,072
Value:								
Total dollars	694,795	2,265,757	2,960,552	431,974	273,820	584,660	1,290,454	4,251,006
Average price cents per Mcf	216.73	73.86	87.38	248.58	238.37	154.44	193.41	104.82

[1] Imported by truck.

Source: Federal Power Commission.

Table 25.—Natural gas: World production by country

(Million cubic feet)

Country [1]	1971		1972		1973 [p]	
	Gross production [2]	Marketed production [3]	Gross production [2]	Marketed production [3]	Gross production [2]	Marketed production [3]
North America:						
Barbados	129	106	123	85	[e] 120	[e] 85
Canada	2,825,904	2,499,024	3,316,153	2,913,537	3,587,000	3,152,410
Mexico	643,416	478,552	660,232	496,019	676,750	[e] 510,000
Trinidad and Tobago	109,814	65,074	104,307	67,150	119,979	64,385
United States	24,088,031	22,493,012	24,016,109	22,531,698	24,067,202	22,647,549
South America:						
Argentina	[r] 286,651	[r] 228,121	277,643	218,350	314,807	[e] 235,000
Bolivia	[r] 81,101	1,427	120,965	37,552	151,199	57,857
Brazil	41,566	[e] 8,300	43,861	[e] 8,500	41,668	[e] 8,300
Chile [4]	282,034	126,252	285,074	144,051	273,209	144,937
Colombia	111,288	51,186	115,622	60,988	113,229	59,966
Ecuador	9,620	[e] 500	5,328	[e] 500	12,269	[e] 1,000
Peru	[r] 67,915	[r] 16,937	64,440	17,164	[e] 68,000	[e] 18,000
Venezuela	1,680,252	368,230	1,625,196	387,723	1,745,726	459,943
Europe:						
Albania	[5] 4,453	4,453	[e] [5] 5,032	[e] 5,032	[e] [5] 5,500	[e] 5,500
Austria	66,790	64,293	69,327	65,459	80,163	80,093
Belgium [6]	[5] 1,780	1,780	[5] 1,695	1,695	[e] [5] 1,900	[e] 1,900
Bulgaria	[r] [5] 11,547	[r] 11,547	[5] 7,769	7,769	[e] [5] 8,000	[e] 8,000
Czechoslovakia [7]	[5] 43,190	43,190	[5] 41,212	41,212	[e] [5] 41,000	[e] 41,000
Denmark [e]	--	--	934	(8)	2,191	(8)
France	380,690	252,463	386,694	260,374	387,118	266,300
Germany, East [6]	[5] 100,752	100,752	[5] 183,635	183,635	[5] 245,000	245,000
Germany, West [7]	562,779	555,194	643,275	633,713	[e] 660,000	[e] 650,000
Hungary [9]	[5] 131,123	131,123	[5] 145,143	145,143	[5] 169,933	169,933
Italy	[r] [5] 472,845	[r] 472,845	[5] 501,009	501,009	[5] 541,267	541,267
Netherlands [7]	1,546,669	1,536,499	2,063,073	2,052,443	2,501,467	2,494,687
Norway [e]	3,123	(8)	18,200	(8)	16,759	(8)
Poland [7]	[r] [5] 190,098	[r] 190,098	[5] 205,636	205,636	[5] 212,840	212,840
Romania	943,568	[r] 891,726	978,667	925,663	1,032,522	[e] 980,000
Spain	[r] [5] 141	[r] 141	[e] [5] 85	[e] 85	[e] 500	[e] 150
U.S.S.R	[e] 7,900,000	7,500,729	[e] 8,200,000	7,818,136	[e] 8,800,000	8,334,222
United Kingdom [7]	[r] [5] 656,814	[r] 656,814	[5] 942,826	942,826	[e] [5] 980,000	[e] 980,000
Yugoslavia	[5] 40,647	40,647	[5] 43,861	43,861	[5] 46,933	46,933
Africa:						
Algeria	[e] 260,000	105,096	[e] 350,000	[e] 110,000	[e] 360,000	[e] 150,000
Angola	[e] 27,000	[e] 1,500	31,393	[e] 2,000	[e] 36,000	[e] 2,300
Congo (Brazzaville)	[r] [5] 535	[r] 535	[5] 523	523	[5] 551	551

See footnotes at end of table.

Table 25.—Natural Gas: World production by country—Continued

(Million cubic feet)

Country[1]	1971		1972		1973[p]	
	Gross production[2]	Marketed production[3]	Gross production[2]	Marketed production[3]	Gross production[2]	Marketed production[3]
Africa—Continued						
Egypt[6]	31,000	3,000	[r] 25,000	2,500	18,000	2,000
Gabon	10,594	[r] 1,095	[e] 12,000	1,201	[e] 14,000	1,402
Libya	556,531	[e] 25,000	496,075	[e] 100,000	562,900	[e] 160,000
Morocco	1,680	1,608	1,822	1,763	2,302	[e] 2,200
Nigeria	[r] 458,167	[r] 3,920	604,639	5,615	[e] 680,000	[e] 6,000
Rwanda[e]	[5] 35	35	[5] 35	35	[5] 35	35
Tunisia	327	35	1,353	699	4,513	4,018
Asia:						
Afghanistan[10]	[r] [5] 93,054	[r] 93,054	[5] 102,200	102,200	[e] [5] 110,000	[e] 110,000
Bahrain	25,364	17,902	63,419	[r] [e] 40,000	82,855	56,575
Bangladesh	[5] 20,000	20,000	[5] 21,900	21,900	[5] 26,000	26,000
Brunei	[e] 120,000	[r] 7,769	[e] 170,000	15,997	[e] 220,000	[e] 200,000
Burma[11]	[e] 8,600	2,333	11,300	3,900	[e] 12,000	5,400
China, People's Republic of[e]	[r] 185,000	80,000	[r] 215,000	90,000	260,000	100,000
India	[r] 53,290	[r] 26,886	55,224	32,736	59,124	32,242
Indonesia	121,158	44,449	146,481	43,562	186,137	28,425
Iran	1,305,228	298,962	1,469,730	447,908	1,698,691	701,678
Iraq	[e] 220,000	30,722	[e] 185,000	[e] 30,000	[e] 250,000	[e] 35,000
Israel	[5] 4,378	4,378	[5] 4,386	4,386	[5] 1,911	1,911
Japan[7 12]	[r] 96,354	[r] 95,574	96,763	95,677	100,442	93,908
Kuwait[13]	643,053	[e] [r] 185,000	660,000	189,437	[e] 605,000	[e] 190,000
Malaysia (Sarawak)	[e] 25,000	2,297	[e] 35,000	3,325	[e] 35,000	3,187
Oman[e]	90,000	1,500	90,000	1,500	90,000	1,500
Pakistan	[5] 107,680	107,680	[5] 118,680	118,680	[5] 132,100	132,100
Qatar	159,418	46,480	[e] 180,000	[e] 52,000	246,185	55,828
Saudi Arabia[13]	938,347	96,050	1,126,974	98,578	[e] 1,440,000	[e] 105,000
Syria[e]	36,000	7,000	40,000	8,000	37,000	7,000
Taiwan	38,520	38,427	44,632	44,186	51,358	[e] 51,000
Turkey[e]	25,000	5,000	24,000	5,000	24,000	5,000
United Arab Emirates:						
Abu Dhabi	365,543	39,749	[e] 412,000	[e] 45,000	520,000	[e] 55,000
Dubai[e]	36,000	10,000	44,000	12,000	55,000	[e] 15,000
Oceania:						
Australia	[5] 79,049	79,049	[5] 112,583	112,583	[5] 144,765	144,765
New Zealand	10,627	8,592	12,484	[e] 9,000	14,824	14,750
Total	[r] 49,437,262	[r] 40,281,692	52,037,722	42,568,899	54,984,944	44,917,032

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition to the countries listed, Cuba, Mongolia, and Thailand produce crude oil and presumably produce natural gas, but available information is inadequate to estimate output levels and the share of gross production that is classifiable as marketed.

[2] Comprises all marketed production (see footnote 3) plus gas vented, flared, reinjected for repressuring, and used to drive turbines (without being burned).

[3] Comprises all gas collected and utilized as fuel or as a chemical industry raw material, including gas used in oilfields and/or gasfields as a fuel by producers, even though it is not actually sold.

[4] Apparently, natural gas that is vented or flared is not included in reported gross production; marketed output presented here is the difference between reported gross production and reported injected into reservoirs.

[5] Gross production not reported; marketed output has been reported in lieu of a gross production estimate because the quantity flared, vented, and/or reinjected is believed to be small.

[6] Total production is obtained from coal mines.

[7] Includes output from coal mines as follows, in million cubic feet: Czechoslovakia: 1971—12,289; 1972—12,000 (estimate); 1973—12,000 (estimate); West Germany: 1971—20,165; 1972—18,646; 1973—18,000 (estimate); Netherlands: 1971—2,013; 1972—1,236; 1973—1,200 (estimate); Poland: 1971—7,734; 1972—7,770 (estimate); 1973—7,800 (estimate); United Kingdom; 1971—4,838; 1972—4,485; 1973—4,400 (estimate); Japan: 1971—10,418; 1972—9,358; 1973—9,200 (estimate).

[8] No marketed production reported; there probably is some small field use in both Denmark and Norway, and in the case of the latter there was extraction of natural gas liquids reported in 1973, but available information is inadequate to make reliable estimates.

[9] Available statistics, used for both gross and marketed production, comprise marketed production plus gas injected into reservoirs for repressuring, but exclude gas vented and/or flared. In 1968 (latest available figure), gas used for repressuring constituted only 0.4% of the total. Information is inadequate to make a reliable estimate of gas vented and/or flared, but it is believed to be small.

[10] Series revised to reflect output in calendar year from that of year beginning March 21 of that stated used in previous editions.

[11] Data are for year ending June 30 of that stated.

[12] Series revised to include output from coal mines, not previously included.

[13] Includes ½ of production reported for the former Kuwait-Saudi Arabia Neutral Zone.

Natural Gas Liquids

By David A. Carleton [1] and Leonard L. Fanelli [2]

Production of natural gas liquids at natural gas processing plants declined for the first time since late in the 1950's. Production of 634.4 million barrels (1.74 million barrels per day was down 0.6% from that of 1972, reflecting primarily a decline in the availability of natural gas for processing. During the summer and fall months, supply shortfalls of some natural gas liquids were created as consumers increased inventories preparatory to anticipated critical shortages during the 1973–74 winter.

Natural gas liquids are products obtained from the processing of natural gas at natural gasoline plants, cycling plants, and fractionators. Included are ethane, the liquefied petroleum gases (LPG—propane, butane, propane-butane mixtures, and isobutane), natural gasoline, isopentane, plant condensate, and finished products including motor gasoline, special naphthas, kerosine, jet fuel, distillate fuel oil, and miscellaneous products.

Natural gas liquids supplied approximately 3.4% of energy requirements, 4.1% of energy production, and 7.4% of petroleum demand in the United States. Their position in the energy market increased slightly in the past decade. The output was valued at $1.86 billion, up 28% from 1972. The unit value rose 29% to $2.93 per barrel compared with $2.28 per barrel in 1972. The 1973 heating seasons were plagued by supply uncertainties and price fluctuations. Supply patterns were further complicated by inventory anomalies, allocation programs, and conservation efforts. Supply complications combined with abnormally warm heating seasons resulted in dislocations in the fuel usage patterns.

The only major natural gas liquids component to increase significantly in production was ethane. This reflected expanded demand for this product as a petrochemical feedstock and increased recovery capability at processing plants. Production rose nearly 8 million barrels, or 7.5%, in 1973, following a 20-million-barrel increase (25%) in 1972.

A series of events that occurred in 1972 led to considerable dislocation in the propane market in 1973. Price controls instituted in July 1972 froze the price that large oil companies (the historic wholesale buyers) could pay for propane. Concomitantly, small companies, those with less than 30 employees could purchase and sell propane without price controls. As a result, the large companies found it difficult in early 1973 to bid successfully for propane. Furthermore, major natural gas consumers (industrial firms, electric powerplants, and natural gas utilities), fearing a shortage of that product, sought propane as a substitute or standby fuel and were active propane purchasers during the spring and summer. This represented a significant demand for propane and resulted in a major diversion of propane from established markets.

Because of lower-than-normal midyear inventories and the prospect that residential and commercial consumers would not have adequate propane supplies during the 1973–74 winter, President Nixon announced a mandatory propane allocation program which became effective on October 3, 1973. This program was generally successful in that propane was available during the heating season; however, several factors had a moderating impact on demand. These included an unusually warm winter, conservation efforts, and resistance to sharply higher consumer prices.

The average unit value of natural gas liquids production was $2.93 per barrel, an

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increase of 29% from the $2.28 per barrel in 1972. LPG, including ethane, exhibited the greatest increase, 39%, by rising to $2.66 per barrel. All other natural gas liquids items increased in unit value except finished gasoline and naphtha which decreased 8%. The general rise in unit value occurred during the middle 6 months of 1973, because of the following: (1) The marketing diversion referred to above, (2) the fear by retailers that they would be unable to obtain adequate supplies, (3) the general fear of a general natural gas shortage, (4) the embargo on exports to the United States by certain Middle East and African nations, and (5) the unilateral increases in foreign crude oil prices, together with the refineries' authorization to "pass on" to consumers a portion of the increase.

Data presented in this chapter were compiled from operating reports of natural gasoline plants, cycling plants, and fractionators that process natural gas. Included are all natural gas liquids except the small volume considered to be insignificant in national and State totals, recovered at pipeline compressor stations and gas dehydration plants. Plant condensate is included in natural gas liquids; field-separated condensate, however, is included with crude oil. Ethane and liquefied gases such as butane and propane, recovered from the crude oil refining operations, are classed as liquefied refinery gases (LRG) and reported as refinery products.

Annual reports were received from all large producers and distributors and from most of the dealers that sell more than 100,000 gallons of LPG per year. To reflect total shipments, the sample of dealer shipments was expanded by Petroleum Administration for Defense (PAD) districts on the basis of domestic demand in the district.

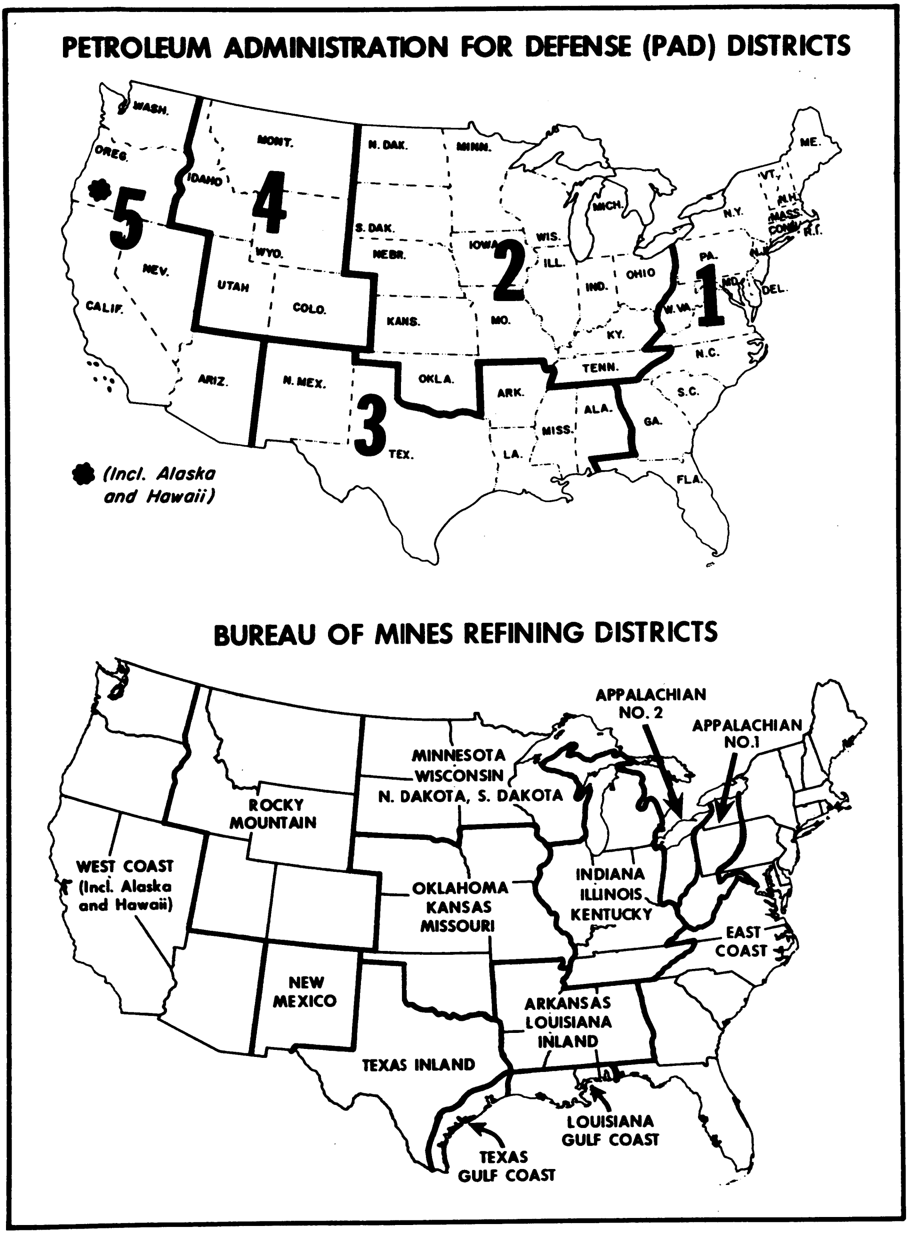

Figure 1.—Maps of PAD Districts and Bureau of Mines Refining Districts.

DOMESTIC PRODUCTION

The overall production of natural gas liquids declined for the first time in over a decade as the availability of natural gas for processing was reduced. Whereas output of most natural gas liquids decreased slightly, the major changes were a 7.5% increase in ethane production and a 2.4% decrease in propane production. The following tabulation presents quantity and percent changes between 1972 and 1973 production of the major natural gas liquids groups:

	Thousand barrels	Percent
Ethane	+7,529	+7.5
LPG:		
Propane	—5,153	—2.4
Other	—79	—.1
Total LPG	—5,232	—1.5
Natural gasoline and isopentane	—1,993	—1.2
Other natural gas liquids	—4,097	—13.8
Total	—3,793	—1.0

There were 786 natural gas processing plants in the United States at the beginning of 1973, down from 805 the previous year. These plants had a natural gas throughput capacity of 73,260 million cubic feet, down 2.5% from 75,137 million cubic feet on January 1, 1972. Nearly 47% of the plants were in Texas, and 17% were in Louisiana.[3] The number of companies operating plants was also down, declining from 131 in 1972 to 125 in 1973.

[3] Oil and Gas Journal. V. 71, No. 28, July 9, 1973, p. 98.

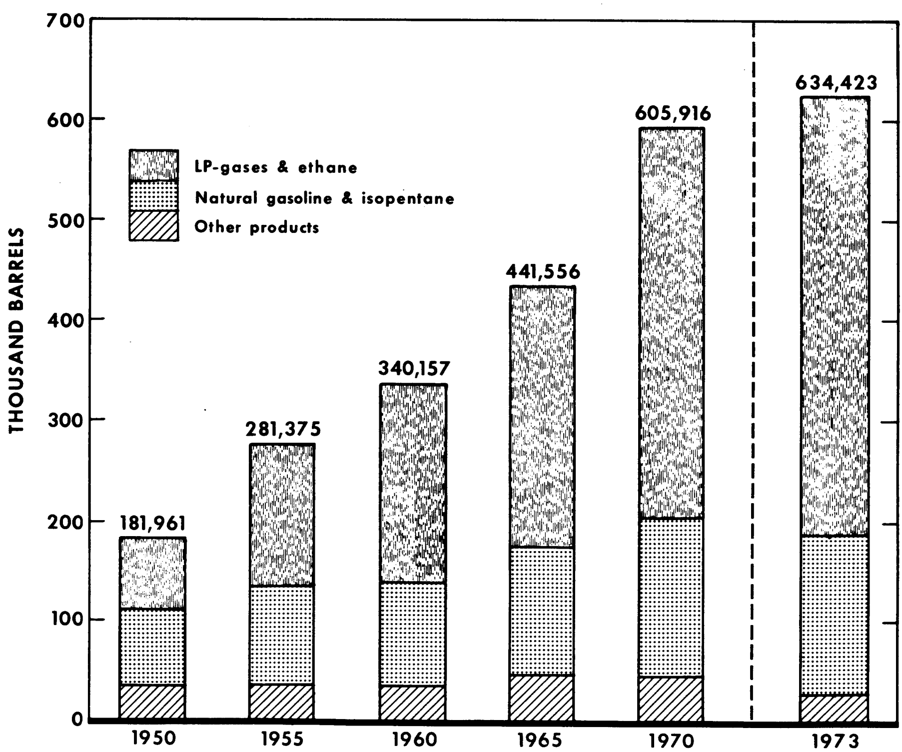

Figure 2.—Production of natural gas liquids in the United States.

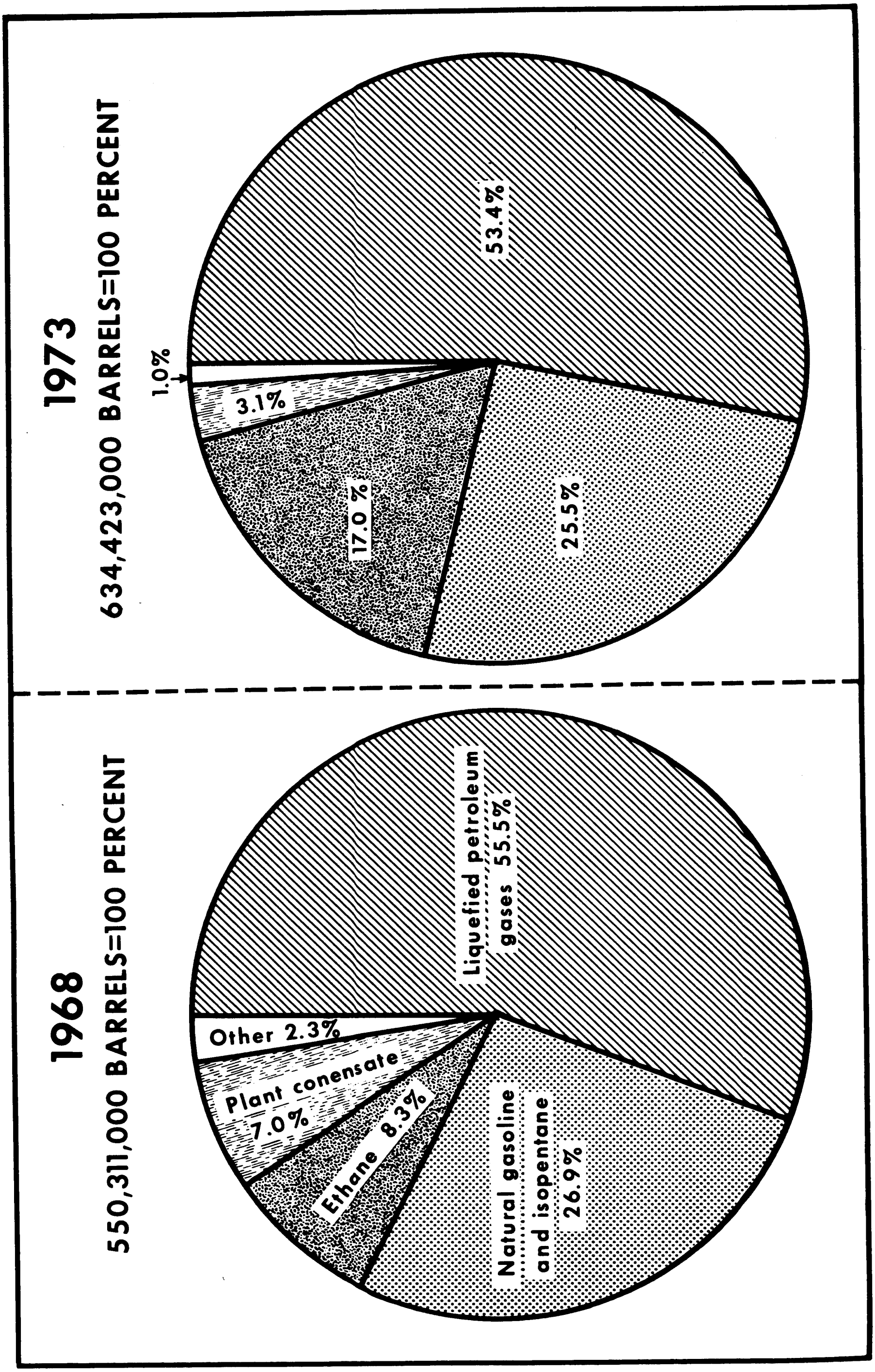

Figure 3.—The relative production of natural gas liquids components, 1968 and 1973.

RESERVES

The American Gas Association (AGA) Reserves Committee estimated that proved reserves of natural gas liquids at yearend 1973 were 6,455 million barrels. This was 5% less than in 1972, and represented the sixth consecutive year in which proved reserves declined since the high of 8,614 million barrels was reached in 1967. Although net changes in reserves by reason of extensions, revisions, and discoveries increased by more than 400 million barrels during the year, this was less than the amount of natural gas liquids produced. According to AGA data, the 1973 reserve-to-production ratio was 8.7:1, compared with 13.4:1 in 1967. A decline in the reserve-to-production ratio from 9.0:1 in 1972 resulted in spite of the greatest increase in new additions to reserves since 1968. Most of the new additions were revisions of estimates of previously proven fields in Texas. States with the largest reserves at yearend 1973 were Texas with 44% of the national total, and Louisiana with 31%. Sizable reserves were also in New Mexico, Kansas and Oklahoma. Louisiana experienced the greatest reduction in reserves, 143 million barrels. Of the States with major reserves, New Mexico had the greatest percentage decline, 18%.

CONSUMPTION AND USES

Liquid products from natural gas liquids plants are generally shipped either to major storage terminals for distribution to retailers and consumers or to refineries for either blending or processing. In 1973, 41% of the natural gas liquids output (about 260.0 million barrels) was shipped to refineries. Inputs to refineries, including 37.5 million barrels of imports, totaled 297.5 million barrels, one-half of which was run to crude oil distillation units and one-half to blending units. The following tabulation shows shipments (inputs) into refineries in 1,000 barrels:

	1972	1973	Percent change
Propane	3,934	2,755	−30.0
Butanes:			
Isobutane	34,629	35,723	+3.2
Normal butane	31,800	25,990	−18.3
Other butanes	11,364	11,267	−8.5
Total butanes	77,793	72,980	−6.2
Butane-propane mix	3,466	4,486	+29.4
Natural gasoline	156,879	154,455	−1.6
Isopentane	7,183	5,895	−17.9
Plant condensate	53,190	56,911	+7.0
Total	302,445	297,482	−1.6

Generally, the lighter natural gas liquids (propane and butane) are blended at refineries, and the heavier items are run to process units. Shipments to storage terminals, including some directly to retailers and consumers, amounted to 374.4 million barrels. Essentially all ethane produced was shipped directly to chemical plants.

PRODUCTIVE CAPACITY

According to the AGA, estimated productive capacity at yearend 1973 was 2,404,000 barrels per day, a decline of 463,000 barrels per day, or 16%, during the year. Each of the top seven States declined in productive capacity during the year. Texas led, losing 190,000 barrels per day (15% of its capacity), followed by Louisiana, 108,000 barrels per day (12%); Kansas, 84,000 barrels per day (37%); New Mexico, 56,000 barrels per day (33%); and Oklahoma 26,000 barrels per day (13%). At yearend the distribution of productive capacity by leading States was: Texas, 43%; Louisiana, 32%; Oklahoma, 7%; Kansas, 6%; and New Mexico, 5%.

As natural gas liquids production is a function of natural gas production and processing, productive capacity is dependent upon rates of gas production from crude oil and natural gas reservoirs. The AGA has defined productive capacity of natural gas liquids as the amount of hydrocarbon liquids that would be produced coincident with the estimated productive capacity of natural gas based on unit recoveries at normal producing rates. Such estimated capacities are not limited by lack of capacity of processing plants or other surface facilities, and it is emphasized that adequate facilities would be required to effect the recovery of liquids from the natural gas produced at these rates. It should also be recognized that such facilities cannot be enlarged quickly. Therefore, the estimated natural gas liquid capacities which relate to increased production of gas from oil and gas wells operating at their productive capacities are theoretical and may not be realized in event of an emergency.[4] Although productive capacity estimates determined in accordance with the above definition are theoretical, they are useful in determining potential availability.

Domestic demand for LPG and liquefied refinery gases (LRG) totaled 409.1 million barrels in 1973, down slightly from 413.6 million barrels in 1972. Of the 1973 domestic demand, 281.4 million barrels was for LPG produced at natural gas processing plants, 89.7 million barrels was for LRG for fuel use and 38.0 million barrels was for LRG for chemical use. Propane (including propylene) demand accounted for 318.0 million barrels, or 77.7% of total LPG and LRG demand. Demand for plant propane was 218.6 million barrels. Refinery propane and propylene demand was 99.4 million barrels, of which 74.1 million barrels was for fuel use and 25.3 million barrels was for chemical use.

Domestic demand for butane (including butylene) increased to 81.7 million barrels. Plant demand was 62.3 million barrels, whereas refinery demand was 19.4 million barrels, of which 12.7 million barrels was for fuel use and 6.7 million barrels was for chemical use.

The domestic demand for ethane (including some ethylene) increased 12% to 119.4 million barrels in 1973. Virtually all ethane was used for petrochemical feedstocks. According to the U.S. Tariff Commission, production of ethylene, the principal use for ethane, increased to a record 22.4 billion pounds in 1973. This compares with 5.9 billion pounds in 1960 and 18.5 billion pounds in 1971.

STOCKS

Stocks of natural gas liquids, which reached a record of 116.2 million barrels on September 30, 1972, fell to critical levels in February 1973. Particularly precarious was propane stocks which totaled 31.7 million barrels and were equivalent to only 24 days of domestic demand. For the corresponding month in 1972, propane stocks were equivalent to 38 days of demand. The February 1973 stocks of propane were of considerable concern since the 1972–73 winter was not exceptionally cold. Propane demand in February 1972 was 14% higher than in February 1973. By yearend 1973, as a result of the demand-constraining factors previously mentioned, stocks had returned to more secure levels, being equivalent to 59 days of December 1973 average daily demand.

Total natural gas liquids stocks at both refineries and plants and bulk terminals at yearend 1973 totaled 98.9 million barrels, 14.7 million barrels more than at yearend 1972. About three-fourths of this total was in underground storage. Natural gas liquids stocks at refineries amounted to 4.8 million barrels, a decrease of 0.2 million barrels from stocks at yearend 1972, whereas stocks at plants and terminals totaled 94.1 million barrels, 14.9 million barrels more than at yearend 1972. By type of liquid, the major yearend stocks changes were for propane, up 11.0 million barrels; butane, up 5.1 million barrels; and ethane, down 2.0 million barrels.

PRICES AND VALUES

The average unit value of natural gas liquids was $2.93 per barrel, up a substantial 29% during the year. The exceptionally large increase resulted from a variety of factors: The general rise in wellhead prices for natural gas, marketing factors resulting from propane shortages during early and mid-1973, efforts to supplement depleted inventories during the

[4] American Gas Association, American Petroleum Institute, and Canadian Petroleum Association. Reserves of Crude Oil, Natural Gas in the United States and Canada and United States Productive Capacity as of December 31, 1973. V. 27, May 1974, p. 108.

Arab embargo on exports to the United States and resultant shortages of petroleum products including liquefied refinery gases, and the diversion of propane and other natural gas liquids into untraditional markets because of the natural gas shortages and the rapidly expanding petrochemical industry.

Future prices for propane increased uniformly throughout the year; however, quotations at supply areas recorded significant increases earlier than those at consuming areas. Average monthly futures increased 9.85 cents per gallon, or 142% at Wood River, Ill., and 8.40 cents per gallon, or 140% at Mt. Belvieu, Tex. New York had the smallest increase; 4.20 cents per gallon, or 46%. Unit price of LPG and ethane increased more than that of other natural gas liquids. The increase was $0.75 per barrel (1.79 cents per gallon), or 39%. The only unit price to decline was that for finished gasoline and naphtha. This suggests that these small amounts were probably contaminated and sold at distressed prices.

FOREIGN TRADE

In 1973 liquefied petroleum gases and plant condensate became the third most important item of liquid hydrocarbon imports, following residual and distillate fuel oils. The 85.3 million barrels imported were 34% greater than 1972 imports. The significant increase was occasioned by the critical shortage in the early part of the year that accompanied efforts to rebuild inventories, and by dwindling supplies associated with the Arab embargo on petroleum exports to the United States. In 1973, the United States imported LPG from 22 countries, compared with only 9 in 1972. Principal among these were Canada and Venezuela which supplied 81% and 15% respectively of the total. Canada accounted for essentially all of the natural gas plant condensate. Canada is providing some of the feedstock for the production of synthetic high Btu gas as shown in plant condensate data in table 17.

Whereas PAD District II was the principal importer of LPG (essentially all from Canada) District III had the greatest increase, rising from 0.8 million barrels in 1972 to 9.1 in 1973. Although some of this was used in the petrochemical industry in PAD III, large amounts were shipped to other districts, principally PAD II and IV for heating and crop drying.

Mexico is the major destination of LPG exports, receiving 92% of the total, followed by Japan (4%) and Canada nearly 4%. Exports were down 13% from 1972, reflecting the propane shortage in the United States. Much of LPG exported to Mexico was used for heating and cooking in border areas. LPG exports comprised butane, 8%; propane, 32%; and butane-propane mixtures, 60%.

WORLD REVIEW

The United States and Canada continued to dominate natural gas plant liquids output, together accounting for an estimated three-fourths of total world production. The U.S.S.R. was also an important producer, ranking third and comprising 8% of the total. Significant gains in output have been made in recent years, especially in major associated natural gas producing countries. Venezuela's production of 33.9 million barrels in 1973 was 33% more than in 1971. Natural gas liquids production from the Middle East's three major producers of associated natural gas, Iran, Kuwait and Saudi Arabia, also reached a record high of 71,259,000 barrels or 36% above 1972. Most of the increase occurred in Saudi Arabia, as evidenced in table 19.

In Canada, the National Energy Board approved a project relating to the export of propane and ethane. Included was a 1.2-billion-pound-per-year ethylene plant located at Fort Saskatchewan using ethane feedstock and two pipelines from Edmonton to Sarnia, one of which is a 12-inch-diameter line for natural gas liquids and the other a 10-inch line for ethylene. Plans are to export over an extended period 169 million barrels of ethane to a synthetic gas plant at Green Springs, Ohio.

Canada, the only foreign country for which natural gas liquid reserves data were available had proved reserves of 1,595 million barrels at the end of 1973. This was down by 108 million barrels and represented the fourth consecutive year of decline.

Atlantic Richfield Co. announced plans to build a $75 million natural gas liquids plant in the Java Sea, offshore Indonesia. The totally offshore plant will process natural gas associated with the offshore Ardjuna oilfield about 90 miles north of Djarkata. Construction was scheduled to begin in mid-1974, and operation was set for 1975.

The National Iranian Oil Co. (NIOC) and Transco Companies, Inc. of the United States will be equal partners in a $650 million natural gas liquids project to be built in southwestern Iran. About 750 million cubic feet per day of associated gas from five oilfields will be run to six extraction plants, which will produce 60,000 barrels per day of natural gas liquids. The product will be one-third propane, one-third butane, and one-third pentane plus. The liquids will be moved in a 12-inch pipeline to Kharg Island where they will be shipped to Transco's previously announced $85 million synthetic gas plant in eastern Pennsylvania.

Plans are underway in Kuwait to double the existing natural gas liquids output, which reached 22.1 million barrels in 1973.

The consortium Santo-Delhi-Vamgos, plans to complete a natural-gas-processing plant at Moomba in Australia in 1977. The output will be feedstock for a petrochemical plant planned by Redcliffs, S.A.

Other natural gas processing plants planned or under construction include expanding the 5.2-million-barrel-per year propane-butane plant at Hassi Messaud Algeria, to 8.6 million barrels per day; completion of a 700,000-barrel-per-year LPG plant in Santa Fe Province in Argentina; increasing the 1.5-million-barrel-per-year processing plant at Nienburg, West Germany, to 4.2 million barrels per year, and expanding and constructing 12 plants in Canada, having a combined capacity of 130 million barrels per year. The largest of these was a 34-million-ton-per-year plant at Brazcau, Alberta.

The joint venture of Broken Hill Pty. Co., Ltd., and ESSO Australia, Ltd., that operates the only natural gas processing plant in Australia at Longford, Victoria, announced that capacity will be doubled. When completed in mid-1975, the plant is expected to produce 53,000 barrels per day of propane and butane and 12,500 barrels per day of ethane.

The Hungarian Oil and Gas Trust completed the first stage of its natural gas-processing plant at Szank. The plant can process 141 million cubic feet per day of associated natural gas from fields in the Szeged area. The plant was built with the assistance of U.S.S.R. technicians. The annual output capacity is as follows:

	Thousand barrels
Propane and butane	1,438
Isobutane	464
Isopentane	418
Natural gasoline	1,800
	4,120

Plans are to double the capacity by 1975.

Table 1.—Plant production, stocks at plants and terminals, shipments from plants of natural gas processing plant products in 1973

(Thousand barrels)

Product	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total 1973	Total 1972
Ethane:														
Production	8,999	8,417	9,725	8,805	9,097	8,602	8,792	8,966	8,670	9,316	9,272	9,559	108,220	100,691
Stocks	7,139	7,126	7,173	6,869	6,976	6,733	6,734	6,374	6,193	6,139	5,381	5,023	5,023	7,052
Shipments	8,912	8,430	9,678	9,109	8,990	8,845	8,791	9,326	8,851	9,370	10,030	9,917	110,249	97,004
Liquefied petroleum gases:														
Production	28,377	26,980	28,925	28,924	29,317	28,163	27,720	27,649	27,361	28,661	27,985	28,751	338,813	344,045
Stocks	52,835	44,657	47,164	53,764	62,180	71,277	81,612	87,236	92,196	92,262	87,128	83,086	83,086	67,807
Shipments	43,349	35,158	26,418	22,324	20,901	19,066	17,385	22,025	22,401	28,595	33,119	32,793	323,534	356,532
Isopentane:														
Production	537	425	470	466	507	504	480	470	461	496	430	582	5,828	7,251
Stocks	69	63	40	31	25	35	28	28	26	26	25	32	32	99
Shipments	567	431	493	475	513	494	487	470	463	496	431	575	5,895	7,183
Natural gasoline:														
Production	11,822	10,935	12,308	12,010	12,668	12,650	14,755	15,055	13,747	13,890	13,460	12,580	155,880	156,450
Stocks	3,396	3,273	3,145	3,607	3,788	4,192	4,226	4,576	4,642	4,975	4,992	5,043	5,043	3,285
Shipments	11,711	11,058	12,436	11,548	12,487	12,246	14,721	14,705	13,681	13,557	13,443	12,529	154,122	156,812
Plant condensate:														
Production	1,733	1,558	1,737	1,716	1,757	1,475	1,674	1,615	1,567	1,648	1,664	1,694	19,838	22,022
Stocks	677	649	695	754	739	649	567	623	655	624	627	739	739	763
Shipments	1,819	1,586	1,691	1,657	1,772	1,565	1,756	1,559	1,535	1,679	1,661	1,582	19,862	21,853
Motor gasoline:														
Production	327	288	330	301	307	199	211	212	218	218	205	213	3,029	4,182
Stocks	131	117	151	169	120	92	84	67	81	85	75	83	83	124
Shipments	320	302	296	283	356	227	219	229	204	214	215	205	3,070	4,285
Special naphthas:														
Production	19	19	20	21	19	17	17	17	15	16	15	15	210	264
Stocks	8	10	9	9	7	5	4	4	4	5	4	7	7	8
Shipments	19	17	21	21	21	19	18	17	15	15	16	12	211	267
Other products:														
Kerosine:														
Production	69	72	78	71	71	47	49	51	51	51	48	46	704	1,063
Stocks	38	52	51	53	66	33	41	37	54	47	37	37	37	43
Shipments	74	58	79	69	58	80	41	55	34	58	58	46	710	1,221
Distillate fuel oil:														
Production	97	73	85	76	85	64	62	56	60	62	58	57	835	1,220
Stocks	35	34	29	25	27	25	32	33	38	35	36	40	40	35
Shipments	97	74	90	80	83	66	55	55	55	65	57	53	830	1,223
Miscellaneous products:														
Production	101	90	91	98	89	80	86	92	83	86	82	88	1,066	r 1,028
Stocks	15	16	14	16	14	16	34	18	18	17	15	16	16	r 22
Shipments	108	89	93	96	91	78	68	108	83	87	84	87	1,072	r 1,017
Other products total:														
Production	267	235	254	245	245	191	197	199	194	199	188	191	2,605	3,311
Stocks	88	102	94	94	107	74	107	88	110	99	88	93	93	100
Shipments	279	221	262	245	232	224	164	218	172	210	199	186	2,612	3,461
All products, total:														
Production	52,081	48,857	53,769	52,488	53,917	51,801	53,846	54,183	52,233	54,444	53,219	53,585	634,423	638,216
Stocks	64,343	55,997	58,471	65,297	73,942	83,057	93,362	98,996	103,907	104,215	98,320	94,106	94,106	79,238
Shipments	66,976	57,203	51,295	45,662	45,272	42,686	43,541	48,549	47,322	54,136	59,114	57,799	619,555	[1] 647,399

r Revised.
[1] Includes 2 thousand barrels of jet fuel.

Table 2.—Total production of products of natural gas processing plants, by State and month, 1973

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Arkansas	54	49	52	44	44	47	67	63	52	61	57	63	653
California	1,060	972	1,079	1,045	1,062	1,007	1,035	1,005	977	1,014	953	985	12,194
Colorado	263	252	270	263	291	287	283	305	296	311	292	289	3,402
Florida, Pennsylvania, West Virginia	713	693	817	714	433	676	741	746	717	736	772	796	8,554
Illinois and Kentucky	874	830	1,017	1,077	1,124	1,085	1,064	1,077	1,081	1,114	1,000	1,130	12,473
Kansas	2,780	2,558	2,732	2,482	2,441	2,375	2,477	2,329	2,584	2,444	2,544	2,710	30,456
Louisiana	12,810	11,831	13,261	12,860	12,922	12,221	12,449	12,722	11,870	12,773	12,031	12,857	150,607
Michigan	99	91	92	96	105	92	96	82	76	77	79	78	1,063
Mississippi and Alabama	60	56	65	62	64	57	62	66	59	61	53	52	717
Montana, Utah, Alaska	278	252	282	282	312	306	310	307	277	280	453	484	3,823
Nebraska and North Dakota	185	183	188	184	195	186	193	193	189	189	184	177	2,246
New Mexico	3,206	2,896	3,271	3,097	3,369	3,233	3,366	3,457	3,313	3,475	3,376	3,441	39,500
Oklahoma	3,495	3,311	3,755	3,608	3,654	3,511	3,607	3,652	3,649	3,749	3,866	3,861	43,718
Texas	25,296	24,052	26,005	25,817	29,964	25,855	27,212	27,344	26,221	27,262	26,661	25,740	314,429
Wyoming	908	831	883	857	937	863	884	835	872	898	898	922	10,588
Total United States	52,081	48,857	53,769	52,488	53,917	51,801	53,846	54,183	52,233	54,444	53,219	53,585	634,423

Table 3.—Production of natural gas liquids at natural gas processing plants, and disposition of residue gas in the United States in 1972–73, by State

(Million cubic feet at 14.73 psia at 60°F unless otherwise stated)

State	Total natural gas liquids and ethane production (thousand 42-gallon barrels)	Natural gas processed	Extraction loss (shrinkage)	Disposition of residue gas: Used at plants	Returned to formation	Vented or flared	Shipped to transmission companies	Direct deliveries to consumers	Unaccounted for	Total
1972:										
Arkansas	807	r 28,027	1,197	3,056	241	14	r 20,257	3,262	--	r 26,830
California	12,028	311,947	24,156	20,775	138,387	409	89,638	35,771	2,811	287,791
Colorado	2,994	104,116	4,114	2,787	5,148	240	91,938	--	−111	100,002
Florida, Pennsylvania, West Virginia	8,118	326,092	11,625	4,119	22	--	309,466	797	63	314,467
Illinois and Kentucky	12,707	376,310	19,409	2,716	--	--	351,114	2,933	138	356,901
Kansas	30,604	1,497,319	40,738	9,268	1,884	82	1,374,268	71,362	−283	1,456,581
Louisiana	151,075	6,337,328	197,967	106,614	123,331	3,022	5,190,052	719,411	−3,069	6,139,361
Michigan	1,228	r 43,810	1,912	1,624	811	113	r 39,654	--	−304	r 41,898
Mississippi and Alabama	829	29,538	1,301	1,426	4,837	--	21,116	826	32	28,237
Montana, Utah, Alaska	5,726	136,474	4,970	5,836	83,094	7,695	33,255	--	1,624	131,504
Nebraska and North Dakota	2,429	35,021	3,738	4,174	6,849	83	19,905	85	187	31,283
New Mexico	38,197	1,126,192	54,157	53,218	5,528	2,714	856,568	146,671	7,336	1,072,035
Oklahoma	41,707	1,116,872	56,376	45,604	76,872	207	842,165	92,869	2,779	1,060,496
Texas	319,061	8,139,408	470,105	317,136	931,461	9,825	5,566,168	811,374	33,339	7,669,303
Wyoming	10,706	298,439	16,228	9,692	13,636	566	248,432	9,407	478	282,211
Total	638,216	r 19,906,893	907,993	588,045	1,392,101	24,970	r 15,053,996	1,894,768	45,020	r 18,998,900
1973:										
Arkansas	653	26,135	1,118	2,513	194	8	20,030	2,618	−346	25,017
California	12,194	276,385	17,498	19,563	131,636	--	71,949	33,420	2,319	258,887
Colorado	3,402	110,662	4,674	3,107	4,145	109	98,747	--	−120	105,988
Florida, Pennsylvania, West Virginia	8,554	375,090	12,385	4,391	11	--	357,722	581	--	362,705
Illinois and Kentucky	12,473	358,142	18,975	2,793	--	--	333,518	2,681	175	339,167
Kansas	30,456	1,503,660	43,909	9,746	1,678	65	1,366,017	82,363	−118	1,459,751
Louisiana	150,607	6,524,729	206,833	108,812	130,323	2,863	5,213,818	866,070	−3,990	6,317,896
Michigan	1,063	37,384	1,581	1,295	1,778	61	32,743	--	−74	35,803
Mississippi and Alabama	717	29,081	1,077	1,590	3,605	--	20,746	1,991	72	28,004
Montana, Utah, Alaska	3,823	140,416	5,393	6,175	92,070	1,819	29,871	6,906	−1,818	135,023
Nebraska and North Dakota	2,246	33,369	3,443	3,305	6,266	87	19,858	--	410	29,926
New Mexico	39,500	1,101,341	55,782	48,582	4,764	3,178	860,313	122,409	6,313	1,045,559
Oklahoma	43,718	1,175,548	61,647	49,710	77,372	1,078	897,361	84,793	3,587	1,113,901
Texas	314,429	7,683,830	466,143	299,738	823,369	7,671	5,279,049	748,629	59,231	7,217,687
Wyoming	10,588	303,519	16,093	10,386	10,946	576	257,539	8,722	−743	287,426
Total	634,423	19,679,291	916,551	571,706	1,288,157	17,515	14,859,281	1,961,183	64,898	18,762,740

r Revised.

Table 4.—Natural gas liquids production and value at natural gas processing plants, by State and product

State	Number of operating companies[1]	LPG and ethane			Natural gasoline and isopentane			Plant condensate		
		Quantity (thousand barrels)	Value (thousands)	Dollars per barrel[2]	Quantity (thousand barrels)	Value (thousands)	Dollars per barrel[2]	Quantity (thousand barrels)	Value (thousands)	Dollars per barrel[2]
Arkansas	4	449	$1,688	$3.76	187	$797	$4.26	6	$27	$4.45
California	20	5,329	19,824	3.72	6,352	21,279	3.35	513	2,196	4.28
Colorado	8	1,978	6,488	3.28	1,414	4,256	3.01	10	39	3.91
Florida, Pennsylvania, West Virginia	5	7,477	21,530	2.88	1,077	3,632	3.37	--	--	--
Illinois and Kentucky	3	11,970	34,813	2.91	499	1,765	3.54	4	15	3.75
Kansas	12	24,463	53,819	2.20	5,986	17,659	2.95	5	20	3.97
Louisiana	35	102,701	253,671	2.47	39,495	133,888	3.39	4,446	18,406	4.14
Michigan	3	691	2,529	3.66	366	1,168	3.19	4	14	3.61
Mississippi and Alabama	4	383	1,452	3.79	280	974	3.48	46	200	4.35
Montana, Utah, Alaska	8	2,236	5,773	2.58	1,580	6,360	4.03	7	27	3.86
Nebraska and North Dakota	5	1,737	4,819	2.77	506	1,668	3.30	3	12	4.00
New Mexico	11	29,652	74,427	2.51	9,519	31,318	3.29	281	992	3.53
Oklahoma	35	29,044	95,264	3.28	13,728	45,714	3.33	825	2,970	3.60
Texas	68	221,686	589,685	2.66	77,681	288,197	3.71	13,375	52,163	3.90
Wyoming	18	7,237	22,507	3.11	3,038	9,539	3.14	313	1,108	3.54
Total	125	447,033	1,188,289	2.66	161,708	568,214	3.51	19,838	78,189	3.94

State	Number of operating companies[1]	Finished gasoline and naphtha			Other products[3]			Total		
		Quantity (thousand barrels)	Value (thousands)	Dollars per barrel[2]	Quantity (thousand barrels)	Value (thousands)	Dollars per barrel[2]	Quantity (thousand barrels)	Value (thousands)	Dollars per barrel[2]
Arkansas	4	--	--	--	11	$37	$3.40	653	$2,549	$3.90
California	20	--	--	--	--	--	--	12,194	43,299	3.55
Colorado	8	--	--	--	--	--	--	3,402	10,783	3.17
Florida, Pennsylvania, West Virginia	5	--	--	--	--	--	--	8,554	25,162	2.94
Illinois and Kentucky	3	--	--	--	--	--	--	12,473	36,593	2.93
Kansas	12	--	--	--	2	6	3.11	30,456	71,504	2.35
Louisiana	35	2,349	$9,443	$4.02	1,616	5,300	3.28	150,607	420,708	2.79
Michigan	3	--	--	--	2	7	3.26	1,063	3,718	3.50
Mississippi and Alabama	4	--	--	--	8	30	3.75	717	2,656	3.70
Montana, Utah, Alaska	8	--	--	--	--	--	--	3,823	12,160	3.18
Nebraska and North Dakota	5	--	--	--	--	--	--	2,246	6,499	2.89
New Mexico	11	--	--	--	48	139	2.90	39,500	106,876	2.71
Oklahoma	35	--	--	--	121	386	3.19	43,718	144,334	3.30
Texas	68	890	4,459	5.01	797	2,574	3.23	314,429	937,078	2.98
Wyoming	18	--	--	--	--	--	--	10,588	33,154	3.13
Total	125	3,239	13,902	4.29	2,605	8,479	3.25	634,423	1,857,073	2.93

[1] A producer operating in more than 1 State is counted only once in arriving at U.S. total.
[2] Represents average unit value of sales throughout the year.
[3] Includes kerosine, distillate fuel oil, and miscellaneous products.

Source: Company reports and Bureau of Mines estimates.

Table 5.—Production of natural gas liquids and ethane at natural gas processing plants in the United States in 1973

(Thousand barrels)

PAD Districts and States	Ethane	Liquefied petroleum gases						Natural gasoline and isopentane	Plant condensate	Finished gasoline and naphtha	All other products [1]	Total
		Propane	Normal butane	Other butanes	Butane-propane mixture	Isobutane	Total					
District I	([2])	3,759	929	777	--	291	5,756	([2])	--	--	--	8,554
District II:												
Michigan	--	463	85	39	94	10	691	366	4	--	2	1,063
Kansas	3,744	14,266	3,975	1,074	3	1,401	20,719	5,986	5	--	2	30,456
Nebraska and North Dakota	15	1,058	612	52	--	--	1,722	506	3	--	--	2,246
Oklahoma	1,908	18,089	4,929	2,546	30	1,542	27,136	13,728	825	--	121	43,718
Other States [3]	[2] 9,172	3,457	656	--	--	406	4,519	[2] 1,576	4	--	--	12,473
Total District II	[2] 14,839	37,333	10,257	3,711	127	3,359	54,787	[2] 22,162	841	--	125	89,956
District III:												
Alabama and Mississippi	--	161	114	--	108	--	383	280	46	--	8	717
Arkansas	--	238	103	37	--	71	449	187	6	--	11	653
Louisiana:												
Gulf	31,191	40,547	12,588	610	81	12,352	66,178	38,173	3,893	1,513	1,279	142,227
Inland	1,229	2,350	841	184	141	587	4,103	1,322	553	836	337	8,380
Total Louisiana	32,420	42,897	13,429	794	222	12,939	70,281	39,495	4,446	2,349	1,616	150,607
New Mexico	4,283	14,533	4,573	4,201	294	1,768	25,369	9,519	281	--	48	39,500
Texas:												
Gulf	16,475	15,986	5,401	575	681	4,331	26,974	13,187	2,004	209	169	59,018
West	21,441	45,381	12,364	4,969	205	3,244	66,163	25,466	3,204	--	9	116,283
East (field)	774	3,345	2,139	--	--	532	6,016	2,049	37	--	37	8,913
Panhandle	892	14,006	3,087	7,454	21	1,626	26,194	11,957	33	--	48	39,124
Other	17,051	24,151	7,283	1,829	1,681	4,762	39,706	25,022	8,097	681	534	91,091
Total Texas	56,633	102,869	30,274	14,827	2,588	14,495	165,053	77,681	13,375	890	797	314,429
Total District III	93,336	160,698	48,493	19,859	3,212	29,273	261,535	127,162	18,154	3,239	2,480	505,906
District IV:												
Colorado	--	1,253	55	670	--	--	1,978	1,414	10	--	--	3,402
Montana and Utah	--	1,423	720	12	--	81	2,236	868	7	--	--	3,111
Wyoming	45	4,132	1,459	1,382	--	219	7,192	3,038	313	--	--	10,588
Total District IV	45	6,808	2,234	2,064	--	300	11,406	5,320	330	--	--	17,101
District V	--	4,288	234	208	170	429	5,329	7,064	513	--	--	12,906
Total United States	108,220	212,886	62,147	26,619	3,509	33,652	338,813	161,708	19,838	3,239	2,605	634,423

[1] Includes jet fuel, kerosine, distillate, and other.
[2] District I ethane and natural gasoline and isopentane data included with District II, Other States.
[3] Other States includes Florida, Illinois, Kentucky, Pennsylvania and West Virginia for ethane and natural gasoline and isopentane only.

Table 6.—Production of natural gasoline by vapor pressure and PAD district in the United States, in 1973

(Thousand barrels)

Reid vapor pressure	District I	District II	District III	District IV	District V	Total
12 pounds and less	251	2,811	62,918	925	830	67,735
Over 12 pounds including 14 pounds	815	6,174	21,668	1,892	40	30,589
Over 14 pounds including 18 pounds	--	4,373	7,754	837	119	13,083
Over 18 pounds including 22 pounds	11	593	859	50	1,193	2,706
Over 22 pounds including 26 pounds	--	1,289	12,808	203	966	15,266
Over 26 pounds	--	5,556	15,747	1,282	3,916	26,501
Total	1,077	20,796	121,754	5,189	7,064	155,880

Table 7.—Comparison of 1972 and 1973 gas liquids production and value

	Thousand barrels		Percent change	Thousand dollars		Percent change	Dollars per barrel		Percent change
	1972	1973		1972	1973		1972	1973	
LPG and ethane	444,736	447,033	+0.5	847,810	1,188,289	+40.2	1.91	2.66	+39.3
Natural gasoline and isopentane	163,701	161,708	−1.2	500,425	568,214	+13.6	3.06	3.51	+14.7
Plant condensate	22,022	19,838	−9.9	74,728	78,189	+4.6	3.39	3.94	+16.2
Finished gasoline and naphthas	4,446	3,239	−27.1	20,737	13,902	−33.0	4.66	4.29	−7.9
Other products	3,311	2,605	−21.3	8,533	8,479	−.6	2.58	3.25	+26.0
Total or average	638,216	634,423	−.6	1,452,233	1,857,073	+27.9	2.28	2.93	+28.5

Table 8.—Estimated proved recoverable reserves of natural gas liquids in the United States

(Thousand barrels)

State	Reserves Dec. 31, 1972	Changes in reserves in 1973		Reserves Dec. 31, 1973		
		Extensions and revisions	New field and new reservoir discoveries	Non-associated	Associated—dissolved	Total
Alabama	27,606	+16,617	1,080	43,408	1,184	44,592
Alaska	442	--	--	--	343	343
Arkansas	7,778	−1,611	--	3,364	1,680	5,044
California [1]	126,726	−8,452	150	3,195	102,768	105,963
Colorado	16,079	+7,536	5	10,534	10,319	20,853
Florida	8,800	−5,159	--	--	3,307	3,307
Illinois	814	−814	--	--	--	--
Indiana	14	−14	--	--	--	--
Kansas	393,082	+23,779	1,039	378,555	8,743	387,298
Kentucky	46,782	+423	1,204	45,324	--	45,324
Louisiana [1]	2,135,837	+75,137	28,483	1,672,350	320,187	1,992,537
Michigan	19,026	+1,989	5,514	7,507	17,539	25,046
Mississippi	14,620	+721	248	7,495	6,595	14,090
Montana	4,413	−97	--	694	2,931	3,625
Nebraska	1,630	+13	--	511	781	1,292
New Mexico	502,787	−51,533	232	294,227	118,953	413,180
North Dakota	45,367	+10,000	--	79	53,266	53,345
Oklahoma	335,161	−8,277	2,318	189,714	99,388	289,102
Pennsylvania	735	--	--	659	--	659
Texas [1]	2,891,583	+261,819	14,685	1,341,127	1,489,016	2,830,143
Utah	34,002	+20,927	--	472	52,072	52,544
West Virginia	82,084	+5,627	695	82,755	--	82,755
Wyoming	91,191	+4,664	31	42,061	41,604	83,665
Total	6,786,559	+353,295	55,684	4,124,031	2,330,676	6,454,707

[1] Includes offshore.

Source: American Gas Association.

Table 9.—Estimated productive capacity of natural gas liquids in the United States [1]

(Thousand barrels per day)

State	Productive capacity: Non-associated	Associated—dissolved	Total
Alabama	2	1	3
Arkansas	2	1	3
California [2]	1	43	44
Colorado	4	6	10
Florida	--	1	1
Kansas	135	9	144
Kentucky	8	--	8
Louisiana [2]	679	97	776
Michigan	5	6	11
Mississippi	2	3	5
Montana	1	2	3
Nebraska	1	1	2
New Mexico	64	48	112
North Dakota	--	6	6
Oklahoma	112	66	178
Texas [2]	575	464	1,039
Utah	1	7	8
West Virginia	15	--	15
Wyoming	15	21	36
Total	1,622	782	2,404

[1] During the heating season immediately following Dec. 31, 1973.
[2] Includes offshore productive capacity.

Source: American Gas Association.

Table 10.—Production, stocks, and demand of liquefied gases and ethane at gas-processing plants and refineries

(Thousand barrels)

	Ethane	Propane	Butane	Butane-propane mixtures	Isobutane	Total
Production:						
At gas-processing plants	108,220	212,886	88,766	3,509	33,652	447,033
At refineries:						
For fuel use	--	73,531	13,036	3,003	--	89,570
For chemical use	9,194	25,329	6,666	3,491	2,576	47,256
Total	117,414	311,746	108,468	10,003	36,228	583,859
Net change in stocks:						
Liquefied petroleum gases:						
At gas-processing plants	−2,029	11,485	4,900	−118	−988	13,250
At refineries	--	167	−56	97	−472	−264
Liquefied refinery gases:						
For fuel use	--	−560	310	166	--	−84
For chemical use	--	22	1	1	26	50
Exports	--	5,501	4,455	--	--	9,956
Imports	--	25,614	22,187	--	--	47,801
Use at refineries	--	2,755	39,327	3,027	35,112	80,221
Domestic demand:						
At gas-processing plants	110,249	218,592	62,327	503	--	391,671
At refineries:						
For fuel use	--	74,091	12,726	2,837	--	89,654
For chemical use	9,194	25,335	6,665	3,490	2,550	47,234
Total	119,443	318,018	81,718	6,830	2,550	528,559
Yearend stocks:						
Liquefied petroleum gases:						
At gas-processing plants	5,023	59,704	15,289	826	7,267	88,109
At refineries	--	357	1,369	128	959	2,813
Liquefied refinery gases:						
For fuel use	--	4,399	2,471	533	--	7,403
For chemical use	--	187	16	3	110	316
Total	5,023	64,647	19,145	1,490	8,336	98,641

Table 11.—Natural gas liquids[1] used as refinery input in the United States in 1973, by Bureau of Mines refinery district and by month

(Thousand barrels)

District	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
East Coast	74	35	33	37	85	28	43	22	30	25	68	21	501
Appalachian	208	299	294	258	229	287	167	212	177	179	313	256	2,879
Indiana, Illinois, Kentucky, etc	3,349	3,156	2,999	2,667	2,792	2,318	2,912	2,623	2,592	2,287	2,423	2,846	32,964
Minnesota, Wisconsin, North Dakota, South Dakota	1,157	1,194	1,212	1,183	1,188	1,101	1,153	1,126	1,057	731	901	1,124	13,127
Oklahoma, Kansas, Missouri	2,096	1,886	1,717	1,629	1,874	1,727	1,913	1,943	2,063	2,210	2,329	2,371	23,758
Texas:													
Inland	2,056	1,707	1,884	1,786	1,927	1,971	2,027	2,070	1,882	1,905	1,930	1,918	23,063
Gulf Coast	9,835	8,374	9,160	8,088	7,763	8,268	10,940	11,015	10,245	10,552	10,287	9,999	114,526
Total	11,891	10,081	11,044	9,874	9,690	10,239	12,967	13,085	12,127	12,457	12,217	11,917	137,589
Louisiana-Arkansas:													
Louisiana Gulf Coast	3,854	3,444	3,690	3,395	3,740	3,511	3,386	3,935	3,662	4,427	4,310	4,292	45,646
Arkansas and Louisiana	266	261	359	316	303	657	471	432	472	502	459	495	4,993
Total	4,120	3,705	4,049	3,711	4,043	4,168	3,857	4,367	4,134	4,929	4,769	4,787	50,639
New Mexico	101	103	83	103	124	112	135	138	136	175	119	129	1,459
Other Rocky Mountain	1,182	1,277	1,389	1,038	1,149	1,096	1,396	1,595	1,191	1,399	1,454	1,075	15,241
West Coast	1,833	1,659	1,675	1,481	1,548	1,623	1.775	1,489	1,485	1,491	1,697	1,570	19,326
Total United States	26,011	23,395	24,495	21,981	22,722	22,699	26,318	26,600	24,992	25,883	26,290	26,096	297,482

[1] Comprised of plant condensate (including imports), natural gasoline, LPG, and isopentane.

Table 12.—Liquefied refinery gases and ethane produced at refineries for fuel and chemical use in 1973

(Thousand barrels)

PAD districts and States	Ethane	Propane	Butane	Butane-propane mixture	Total
District I:					
New Jersey	58	6,450	1,511	210	8,229
Pennsylvania	--	7,213	937	--	8,150
Other States [1]	--	4,058	379	--	4,437
Total District I	58	17,721	2,827	210	20,816
District II:					
Illinois	--	10,912	141	--	11,053
Indiana	--	766	314	--	1,080
Kansas	520	3,978	95	1	4,594
Kentucky	--	815	--	--	815
Michigan	--	1,224	104	2	1,330
Ohio	--	4,473	362	--	4,835
Oklahoma	--	3,145	233	426	3,804
Other States [2]	--	2,246	72	262	2,580
Total District II	520	27,559	1,321	691	30,091
District III:					
Alabama and Mississippi	--	1,727	57	99	1,883
Arkansas	--	178	42	--	220
Louisiana:					
Gulf	2,960	15,350	1,752	2,470	22,532
Inland	--	113	216	154	483
Total Louisiana	2,960	15,463	1,968	2,624	23,015
New Mexico	--	203	166	--	369
Texas:					
Gulf	5,040	22,065	10,588	147	37,840
Inland	108	2,530	857	12	3,507
Total Texas	5,148	24,595	11,445	159	41,347
Total District III	8,108	42,166	13,678	2,882	66,834
District IV:					
Colorado	--	139	189	--	328
Montana	--	784	60	57	901
Utah	--	453	17	23	493
Wyoming	--	226	195	93	514
Total District IV	--	1,602	461	173	2,236
District V	508	9,812	3,991	2,538	16,849
Total United States	9,194	98,860	[3] 22,278	6,494	136,826

[1] Includes Delaware, New York, Virginia, and West Virginia.
[2] Includes Minnesota, Missouri, Nebraska, North Dakota, Tennessee, and Wisconsin.
[3] Includes 2,576,000 barrels of isobutane used for petrochemical feedstock.

Table 13.—Refinery input and stocks of natural gas plant products and refinery output and stocks of liquefied refinery gases, by product

(Thousand barrels)

	PAD Districts					United States
	I	II	III	IV	V	
Natural gas plant products:						
Refinery inputs:						
Propane	--	435	2,278	7	35	2,755
Isobutane	38	12,171	20,877	965	1,672	35,723
Normal butane	148	7,419	14,864	385	3,174	25,990
Other butane	89	6,345	1,839	1,804	1,190	11,267
Butane-propane mix	--	335	2,720	282	1,149	4,486
Natural gasoline	153	19,515	130,465	1,673	8,544	160,350
Plant condensate	2,126	24,455	16,643	10,125	3,562	56,911
Total	2,554	70,675	189,686	15,241	19,326	297,482
Stocks at refineries: [1]						
Propane	--	--	287	70	--	357
Isobutane	--	211	703	23	22	959
Normal butane	--	196	798	20	20	1,034
Other butane	--	35	274	26	--	335
Butane-propane mix	--	4	112	12	--	128
Natural gasoline	--	209	841	4	31	1,085
Plant condensate	--	397	207	330	2	936
Total	--	1,052	3,222	485	75	4,834
Liquefied refinery gases:						
Refinery outputs:						
Propane and/or propylene	17,721	27,559	42,166	1,602	9,812	98,860
Butane and/or butylene	2,827	1,219	12,049	447	3,160	19,702
Butane-propane mix	210	691	2,882	173	2,538	6,494
Isobutane	--	102	1,629	14	831	2,576
Total	20,758	29,571	58,726	2,236	16,341	127,632
Stocks at refineries: [1]						
Propane and/or propylene	843	1,578	1,775	77	313	4,586
Butane and/or butylene	12	460	1,670	12	333	2,487
Butane-propane mix	--	214	11	17	294	536
Isobutane	--	45	9	3	53	110
Total	855	2,297	3,465	109	993	7,719

[1] Stocks as of December 31, 1973.

Table 14.—Refinery input of LPG, by product and PAD district

(Thousand barrels)

Item	PAD district					United States
	I	II	III	IV	V	
1971						
Propane	257	59	2,506	--	451	3,273
Normal butane	686	8,402	15,759	847	3,669	29,363
Other butanes	11	6,105	2,651	1,163	1,191	11,121
Isobutane	24	9,648	19,547	925	2,207	32,351
Butane-propane mix	--	417	2,065	371	734	3,587
Total LPG	978	24,631	42,528	3,306	8,252	79,695
1972						
Propane	--	5	3,851	--	78	3,934
Normal butane	215	9,287	18,171	782	3,345	31,800
Other butanes	53	6,513	2,340	1,238	1,220	11,364
Isobutane	73	10,127	21,817	878	1,734	34,629
Butane-propane mix	--	340	1,880	374	872	3,466
Total LPG	341	26,272	48,059	3,272	7,249	85,193
1973						
Propane	--	435	2,278	7	35	2,755
Normal butane	148	7,419	14,864	385	3,174	25,990
Other butanes	89	6,345	1,839	1,804	1,190	11,267
Isobutane	38	12,171	20,877	965	1,672	35,723
Butane-propane mix	--	335	2,720	282	1,149	4,486
Total LPG	275	26,705	42,578	3,443	7,220	80,221

Table 15.—Stocks of natural gas liquids and ethane in the United States
(Thousand barrels)

Date	LP gases and ethane: At plants and terminals	LP gases and ethane: At refineries	Natural gasoline and isopentane: At plants and terminals	Natural gasoline and isopentane: At refineries	Other finished products and plant condensate: At plants and terminals	Other finished products and plant condensate: At refineries	Total at plants and terminals	Total at refineries	Grand total
Dec. 31:									
1969	53,981	571	3,368	1,557	1,203	232	58,552	2,360	60,912
1970	60,595	794	4,323	1,765	1,074	451	65,992	3,010	69,002
1971	83,659	3,693	3,678	1,485	1,084	419	88,421	5,597	94,018
1972	74,859	3,077	3,384	1,418	995	510	79,238	5,005	84,243
1973:									
Jan. 31	59,974	2,402	3,465	1,360	904	687	64,343	4,449	68,792
Feb. 28	51,783	2,489	3,336	1,424	878	696	55,997	4,609	60,606
Mar. 31	54,337	3,326	3,185	1,418	949	658	58,471	5,402	63,873
Apr. 30	60,633	3,691	3,638	1,535	1,026	743	65,297	5,969	71,266
May 31	69,156	3,942	3,813	1,647	973	1,119	73,942	6,708	80,650
June 30	78,010	3,888	4,227	1,488	820	1,000	83,057	6,376	89,433
July 31	88,346	3,920	4,254	1,399	762	950	93,362	6,269	99,631
Aug. 31	93,610	3,806	4,604	1,410	782	856	98,996	6,072	105,068
Sept. 30	98,389	3,953	4,668	1,249	850	893	103,907	6,095	110,002
Oct. 31	98,401	3,285	5,001	1,362	813	777	104,215	5,424	109,639
Nov. 30	92,509	3,447	5,017	1,373	794	1,052	98,320	5,872	104,192
Dec. 31	88,109	2,813	5,075	1,085	922	936	94,106	4,834	[1] 98,940

[1] Includes 74,787,000 barrels in underground storage.

Table 16.—Average monthly prices, liquefied petroleum gas (propane) in the United States
(Cents per gallon)

	Jan.	Feb.	Mar.	Apr.	May	June	July
New York: [1]							
1972	8.50	8.50	8.50	8.50	8.50	8.50	8.50
1973	9.18	9.18	9.18	9.36	9.48	10.42	10.89
Oklahoma: [1]							
1972	5.25	5.25	5.25	5.25	5.25	5.25	5.25
1973	5.67	5.90	6.46	6.93	8.30	9.28	9.50
Mt. Belvieu, Tex.: [2]							
1972	5.58	5.58	5.58	5.58	5.58	5.58	5.58
1973	6.02	6.21	6.74	7.22	8.39	9.44	9.88
Baton Rouge, La.: [1]							
1972	5.73	5.73	5.73	5.73	5.73	5.73	5.73
1973	6.21	6.40	6.91	7.26	8.49	9.16	9.25
Wood River, Ill.:							
1972	6.45	6.45	6.45	6.45	6.45	6.45	6.45
1973	6.96	6.96	7.15	8.09	8.71	8.79	8.79
Los Angeles, Calif.: 1973	6.72	6.72	6.86	6.92	6.92	7.78	7.78

	Aug.	Sept.	Oct.	Nov.	Dec.	Average for year
New York: [1]						
1972	8.50	8.95	9.18	9.18	9.18	8.71
1973	10.89	12.14	11.69	12.37	13.38	10.68
Oklahoma: [1]						
1972	5.25	5.60	5.67	5.67	5.67	5.38
1973	9.50	11.40	13.83	13.83	13.86	9.58
Mt. Belvieu, Tex.: [2]						
1972	5.58	5.93	6.02	6.02	6.02	5.71
1973	9.88	10.78	12.79	12.97	14.42	9.56
Baton Rouge, La.: [1]						
1972	5.73	6.12	6.21	6.21	6.21	5.88
1973	9.25	10.07	11.50	11.85	13.28	9.13
Wood River, Ill.:						
1972	6.45	6.88	6.96	6.96	6.96	6.61
1973	8.79	11.08	13.56	15.03	16.81	10.06
Los Angeles, Calif.: 1973	7.78	7.78	9.50	10.33	12.74	8.15

[1] Producers' net contract prices (after some discounts and summer-fill allowances) for propane, tank cars, and/or transport trucks.
[2] For pipeline input, minimum 10,000 barrels.
Source: Platt's Oil Price Handbook and Oilmanac.

Table 17.—LPG[1] and plant condensate imported into the United States, by country

(Thousand barrels)

	1971	1972	1973
LPG:			
Algeria	--	--	55
Australia	--	--	38
Belgium	--	--	97
Canada	21,710	27,853	31,653
Chad	--	--	1
Chile	--	126	138
France	--	--	225
Indonesia	8	--	5
Iran	157	--	118
Kuwait	--	5	2
Liberia	--	--	54
Libya	1	120	594
Malaysia	--	68	131
Mexico	4	--	--
Netherlands	--	--	237
Netherlands Antilles	230	--	235
Norway	--	--	103
Oman	--	25	32
Saudi Arabia	350	210	595
Singapore	--	--	1
United Arab Emirates	--	--	9
United Kingdom	--	1	856
Venezuela	3,183	3,993	12,622
Virgin Islands	5	--	--
Other	7	--	--
Total	25,655	32,401	47,801
Imports by PAD District:			
District I	4,775	5,336	8,549
District II	10,859	14,441	18,417
District III	794	787	9,116
District IV	3,060	5,405	5,496
District V	6,167	6,432	6,223
Plant condensate:			
Canada	13,288	31,282	37,460
Venezuela	33	146	15
Total	13,321	31,428	37,475
Total LPG and plant condensate	38,976	63,829	85,276

[1] Includes LRG.

Table 18.—LPG[1] exported from the United States, by country

(Thousand barrels and thousand dollars)

Country	1972 Butane	1972 Propane	1972 Butane-propane mixtures	1972 Total	1973 Butane	1973 Propane	1973 Butane-propane mixtures	1973 Total
Bahamas	(2)	26	(2)	26	(2)	1	--	1
Bahrain	(2)	--	(2)	(2)	--	--	1	1
Belgium	(2)	(2)	--	(2)	1	--	--	1
Bermuda	--	--	(2)	(2)	--	--	1	1
Brazil	47	--	--	47	--	--	(2)	(2)
Canada	10	11	97	118	210	36	116	362
Colombia	(2)	--	--	(2)	--	1	(2)	1
Dominican Republic	1	(2)	--	1	(2)	1	--	1
France	--	28	(2)	28	--	--	(2)	(2)
Finland	--	--	(2)	(2)	--	--	1	1
Germany, West	(2)	--	(2)	(2)	--	(2)	1	1
Guatemala	--	--	5	5	--	1	9	10
Israel	(2)	(2)	--	(2)	(2)	3	--	3
Italy	(2)	(2)	(2)	(2)	(2)	2	(2)	2
Japan	(2)	888	(2)	888	(2)	401	--	401
Mexico	759	2,773	6,798	10,330	537	2,738	5,852	9,127
Netherlands	12	--	(2)	12	--	--	(2)	(2)
New Zealand	2	--	(2)	2	--	1	(2)	1
South Africa, Republic of	--	(2)	1	1	--	(2)	1	1
Spain	(2)	--	(2)	(2)	--	(2)	1	1
United Kingdom	(2)	1	1	2	(2)	(2)	2	2
Other	(2)	9	6	15	3	4	2	9
Total	831	3,736	6.908	11,475	751	3,189	5,987	9,927
Total Value	2,672	23,192	20,717	46,581	3,855	23,345	29,991	57,191

[1] Data include LRG.
[2] Less than ½ unit.

Source: Bureau of the Census.

Table 19.—Natural gas plant liquids:

(Thousand 42-gallon

Country [1]	1971 Propane	Butane	Subtotal	Natural gasoline and other	Total
North America:					
Canada	24,226	15,447	39,673	46,898	86,571
Mexico	NA	NA	[e] 19,000	[e] 2,362	21,362
Trinidad and Tobago	NA	NA	NA	141	141
United States	212,143	92,717	304,860	312,955	617,815
South America:					
Argentina	3,200	3,623	6,823	[e] 1,700	[e] 8,523
Bolivia	NA	NA	48	46	94
Brazil	NA	NA	NA	NA	1,373
Chile	1,092	720	1,812	1,901	3,713
Colombia	1,778	777	2,555	1,073	3,628
Ecuador	NA	NA	52	NA	52
Peru	320	7	327	509	836
Venezuela	NA	NA	16,392	9,152	25,544
Europe:					
France	1,630	1,645	3,275	3,162	6,437
Germany, West	--	--	--	114	114
Italy	--	--	--	589	589
Netherlands	--	--	--	--	--
Poland [e]	NA	NA	NA	NA	235
U.S.S.R. [e 2]	NA	NA	NA	NA	62,000
United Kingdom	--	--	--	1,226	1,226
Yugoslavia	NA	NA	[e] 420	267	[e] 687
Africa:					
Algeria	NA	NA	NA	5,919	5,919
Libya	[e] 200	[e] 600	[e] 800	[e] 1,700	[e] 2,500
Asia:					
Brunei [e]	NA	NA	NA	NA	700
Indonesia	NA	NA	36	NA	36
Iran	3,900	3,400	7,300	3,000	10,300
Japan	NA	NA	123	27	150
Kuwait	7,106	6,558	13,664	5,403	19,067
Pakistan [e]	NA	NA	NA	NA	60
Saudi Arabia	NA	NA	[e] 10,000	[e] 3,000	[e] 13,000
Taiwan	229	212	441	127	568
Oceania: Australia	NA	NA	NA	NA	1,692
Total	[3] 255,824	[3] 125,706	[3] 427,601	[3] 401,271	894,932

[e] Estimate. [p] Preliminary. NA Not available.

[1] In addition to the countries listed, others, including most notably Hungary, New Zealand, the
mation is inadequate to make reliable estimates of output levels. Every effort has been made to
to exclude natural gas liquids obtained from field treatment facilities including wellhead separators,
oil output. In some cases, however, sources do not clearly specify whether data presented represent
country figures in this table may include field condensate. Where this appears to be the case, the

[2] May include field condensate.

[3] Total of listed figures only, and as such represents as incomplete total, because for some coun
sources, and insufficient data are available to estimate the distribution of these totals by individual
does the summation of this subtotal and natural gasoline and other equal the reported natural gas

World production, by country

barrels)

1972					1973 p				
Propane	Butane	Subtotal	Natural gasoline and other	Total	Propane	Butane	Subtotal	Natural gasoline and other	Total
30,431	19,766	50,197	60,674	110,871	34,208	23,055	57,263	62,899	120,162
NA	NA	21,065	2,579	23,644	NA	NA	22,274	4,299	26,573
NA	NA	NA	137	137	--	--	--	79	79
218,039	92,459	310,498	327,718	638,216	212,886	92,275	305,161	329,262	634,423
3,171	4,094	7,265	e 1,800	e 9,065	NA	NA	NA	NA	e 9,000
NA	NA	51	e 100	e 151	e 24	e 24	e 48	e 100	e 148
NA	NA	NA	NA	e 1,400	NA	NA	NA	NA	e 1,400
1,664	1,161	2,825	2,159	4,984	1,811	1,161	2,972	2,075	5,047
1,220	726	1,946	1,016	2,962	1,271	733	2,004	928	2,932
NA	NA	50	119	169	NA	NA	e 50	e 120	e 170
308	2	310	447	757	296	3	299	449	748
NA	NA	20,819	10,116	30,935	NA	NA	23,382	10,487	33,869
1,729	1,893	3,622	3,112	6,734	e 1,800	e 1,900	e 3,700	e 3,100	e 6,800
--	--	--	114	114	--	--	--	e 115	e 115
--	--	--	551	551	--	--	--	e 550	e 550
--	--	--	380	380	--	--	--	e 400	e 400
NA	NA	NA	NA	250	NA	NA	NA	NA	260
NA	NA	NA	NA	67,000	NA	NA	NA	NA	79,000
--	--	--	2,157	2,157	--	--	--	e 2,500	e 2,500
NA	NA	e 420	267	e 687	NA	NA	e 420	e 267	e 687
NA	NA	NA	7,084	7,084	NA	NA	NA	e 12,400	e 12,400
537	2,328	2,865	7,417	10,282	e 530	e 2,290	e 2,820	e 10,000	e 12,820
NA	NA	NA	NA	700	NA	NA	NA	NA	700
NA	NA	e 10	e 30	e 40	NA	NA	10	33	43
4,380	3,639	8,019	3,983	12,002	e 4,910	e 4,170	e 9,080	e 4,580	e 13,660
NA	NA	137	31	168	NA	NA	151	44	195
7,629	7,376	15,005	5,580	20,585	8,478	7,783	16,261	5,888	22,149
NA	NA	NA	NA	65	NA	NA	NA	NA	70
NA	NA	15,784	4,007	19,791	NA	NA	25,628	9,822	35,450
329	303	632	163	795	428	304	732	201	933
NA	NA	13,920	--	13,920	NA	NA	e 13,900	e 3,200	e 17,100
[3] 269,437	[3] 133,747	[3] 475,440	[3] 441,741	986,596	[3] 266,642	[3] 133,698	[3] 486,155	[3] 463,798	1,040,383

People's Republic of China, and Romania, may also produce natural gas plant liquids, but infor-
include in this table only those natural gas liquids produced by natural gas processing plants, and
because the latter are normally blended with crude oil and thus are included in statistics on crude
only output of natural gas processing plants, or if they include field output. Thus, some of the
country has been so footnoted, but it may also be true in the case of other countries.

tries, only total of butane and propane or only total natural gas plant liquids is reported in
type. Summation of totals of propane and butane thus does not equal the reported subtotal, nor
plant liquid total.

Nickel

By John D. Corrick [1]

Nickel supply and demand came into approximate balance throughout the world in the latter part of 1973. Balance was brought about by greatly increased demand in the United States, Western European countries, and Japan. Apparently the 3 years of surplus supply did not alter the course of the nickel industry. The supply base was greatly expanded and the dominance of the International Nickel Co. of Canada Ltd. (Inco) and Société le Nickel S.A. (SLN) of New Caledonia was partly diminished by other nickel producers expanding their production.

Domestic nickel consumption increased 24% in 1973 compared with that of 1972, and exceeded the record consumption in 1966 by 5%. The pattern of nickel consumption was little changed from previous years. However, that portion of nickel consumed in stainless and heat-resisting steels increased at a faster rate in recent years than did nickel consumption in other major end use categories.

The price of nickel in ferronickel was increased 6 to 7 cents per pound at midyear by SLN. Inco followed SLN's lead and increased the price of oxide sinters 90 and 75 by 3 cents per pound. Inco's price was equivalent to those quoted for SLN's ferronickel, recognizing the iron value in ferronickel.

World trade in nickel was singularly marked by the changing supply base. Imports into the United States of Soviet Union nickel for consumption increased nearly fortyfold compared with those of 1972; imports from the Dominican Republic increased about fivefold; and Southern Rhodesian producers supplied nearly 8 million pounds. The United States imported a record 191,000 tons of nickel in 1973.

Legislation and Government Programs.—A proposed rule change regarding rated nickel orders was published in the October 1, 1973, Federal Register. The proposed rule permits nickel producers and distributors to reject rated orders for nickel (other than DX-rated orders and directives issued by the U.S. Department of Commerce, Bureau of Competitive Assessment and Business Policy) that are received by them less than 10 days before the month in which delivery is requested. The proposal also provides that producers and distributors of nickel shall comply with directives, including those that require the set-aside of an individual producer's or distributor's supply of nickel for acceptance of rated orders during specified periods of time.

[1] Physical scientist, Division of Ferrous Metals—Mineral Supply.

Table 1.—Salient nickel statistics

(Short tons)

	1969	1970	1971	1972	1973
United States:					
Mine production [1]	17,056	15,933	17,036	16,864	18,272
Plant production:					
Primary	15,810	15,558	15,654	15,731	13,895
Secondary	18,775	23,159	29,657	35,926	33,295
Exports (gross weight)	34,758	31,456	26,143	21,671	22,070
Imports for consumption	129,332	156,252	142,183	173,870	191,073
Consumption	141,737	155,719	128,802	159,286	197,723
Stocks Dec. 31: Consumer	16,574	24,708	16,005	26,260	28,946
Price cents per pound	103-128	128-133	133	133-153	153
World: Mine production	536,608	692,710	r 702,027	683,122	726,014

r Revised.

[1] Mine shipments.

DOMESTIC PRODUCTION

The Hanna Mining Co. at Riddle, Oreg., was the sole producer of primary nickel in the United States in 1973. By-product nickel salts were produced at copper and other metal refineries; part of the byproduct nickel originated from scrap. Amax Nickel Division of American Metal Climax Inc. began constructing, expanding, and rehabilitating the Port Nickel, La., refinery formerly owned by Freeport Sulphur Co. (Freeport Minerals Co.). The renovated plant will produce 80 million pounds of nickel per year along with varying quantities of copper, cobalt, and ammonium sulfate. Feed material will be in the form of a copper-nickel matte initially imported from Bamangwato Concessions Ltd. (BCL) of Botswana. Considerable interest was expressed in the copper-nickel deposits of Northeastern Minnesota in 1973. Numerous hearings were held by Minnesota's Environmental Quality Council regarding the question of immediate development of the deposits or instituting a moratorium on development. However, at yearend no significant results were reported.

Table 2.—Primary nickel produced in the United States

(Short tons, nickel content)

	1969	1970	1971	1972	1973
Domestic ore	13,096	12,649	13,073	13,226	12,937
Byproduct of metal refining	2,714	2,909	2,581	2,505	958

Table 3.—Nickel recovered from nonferrous scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1972	1973
New scrap:		
Nickel-base	3,038	1,403
Copper-base	1,948	4,598
Aluminum-base	500	600
	5,486	6,601
Old scrap:		
Nickel-base	29,440	25,557
Copper-base	600	637
Aluminum-base	400	500
Total	30,440	26,694
Grand total	35,926	33,295

Form of recovery	1972	1973
As metal	1,166	1,358
In nickel-base alloys	2,694	1,192
In copper-base alloys	6,738	11,739
In aluminum-base alloys	1,056	908
In ferrous and high-temperature alloys [1]	24,003	18,025
In chemical compounds	269	73
Total	35,926	33,295

[1] Includes only nonferrous nickel scrap added to ferrous high-temperature alloys.

CONSUMPTION AND USES

Consumption of ferronickel was an even more significant part of total nickel consumption in the United States in 1973, than it was in 1972. However, the increased usage was due more to the availability and price spread between nickel in ferronickel and that of pure nickel than it was to any change in technology of usage as in the past. Nickel in ferronickel accounted for 18% of the total nickel consumed in 1973, compared with 14% in 1972, and was consumed principally in stainless and alloy steels. The pattern of nickel consumption in 1973 was little changed from that of 1972; 33% of the total consumed was used to make stainless steels, 12% was used in alloy steels, 15% was used in nickel plating, 26% was used to make high-nickel alloys and superalloys, and 2% was used in iron castings. End use market data available to the Bureau of Mines did not indicate any significant change in the worldwide pattern of nickel consumption.

Data on secondary nickel reported in table 8 are incomplete and are based on

November and December reports of approximately 200 companies that report monthly, and the 1973 reports of approximately 450 companies that report annually. The information is included in this chapter to acquaint the reader with the type of material that will be available in future publications and to initiate this series of data. It should be used only as an indicator of secondary nickel consumption.

Table 4.—Stocks and consumption of new and old nickel scrap in the United States in 1973

(Gross weight, short tons)

Class of consumer and type of scrap	Stocks, beginning of year	Receipts	Consumption			Stocks, end of year
			New	Old	Total	
Smelters and refiners:						
Nickel and nickel alloys	2,862	684	753	1,057	1,810	1,736
Monel metal	r 645	2,185	381	2,070	2,451	379
Nickel silver [1]	456	4,186	582	3,571	4,153	489
Cupronickel [1]	140	655	--	528	528	267
Nickel residues	1,936	8,578	7,066	--	7,066	3,448
Total	r 5,443	11,447	8,200	3,127	11,327	5,563
Foundries and plants of other manufacturers:						
Nickel and nickel alloys	3,760	27,072	--	22,964	22,964	7,868
Monel metal	9	102	2	92	94	17
Nickel silver [1]	2,519	17,834	17,671	--	17,671	2,682
Cupronickel [1]	1,622	10,176	10,612	150	10,762	1,036
Nickel residues	109	680	383	276	659	130
Total	3,878	27,854	385	23,332	23,717	8,015
Grand total:						
Nickel and nickel alloys	6,622	27,756	753	24,021	24,774	9,604
Monel metal	654	2,287	383	2,162	2,545	396
Nickel silver [1]	2,975	22,020	18,253	3,571	21,824	3,171
Cupronickel [1]	1,762	10,831	10,612	678	11,290	1,303
Nickel residues	2,045	9,258	7,449	276	7,725	3,578
Total	r 9,321	39,301	8,585	26,459	35,044	13,578

r Revised.
[1] Excluded from totals because it is copper-base scrap, although containing considerable nickel.

Table 5.—Nickel (exclusive of scrap) consumed in the United States, by form [1]

(Short tons)

Form	1969	1970	1971	1972	1973
Metal	99,096	112,825	95,639	110,422	121,821
Ferronickel	17,804	15,230	11,515	22,806	36,371
Oxide powder and oxide sinter	19,133	21,369	16,554	19,315	33,257
Salts	2,647	3,792	2,376	3,939	3,668
Other	3,057	2,503	2,718	2,804	2,606
Total	141,737	155,719	128,802	159,286	197,723

[1] Metallic nickel salts consumed by plating industry are estimated.

Table 6.—U.S. consumption of nickel (exclusive of scrap) in 1973, by use and form

(Short tons)

Use	Commercially pure unwrought nickel	Ferronickel	Nickel oxide	Nickel sulfate and other nickel salts	Other forms	Total of figures shown
Steel:						
Stainless and heat-resisting	17,882	27,837	19,925	--	183	65,827
Alloys (excludes stainless)	7,853	6,562	9,409	--	85	23,909
Superalloys	11,877	476	86	--	342	12,781
Nickel-copper and copper-nickel alloys	7,331	--	43	--	49	7,423
Permanent magnet alloys	5,736	687	343	--	11	6,777
Other nickel and nickel alloys	35,897	390	2,011	5	300	38,603
Cast irons	2,557	414	735	--	1,107	4,813
Electroplating [1]	26,533	--	33	3,218	110	29,894
Chemicals and chemical uses	1,078	--	151	312	9	1,550
Other uses [2]	5,077	5	521	133	410	6,146
Total reported by companies canvassed and estimated	121,821	36,371	33,257	3,668	2,606	197,723

[1] Based on monthly estimated sales to platers.
[2] Includes batteries, ceramics, and other alloys containing nickel.

Table 7.—Nickel (exclusive of scrap) in consumer stocks in the United States, by form

(Short tons)

Form	1971	1972 [r]	1973
Metal	11,499	18,516	11,987
Ferronickel	2,539	3,959	7,792
Oxide powder and oxide sinter	970	2,806	8,018
Salts	381	477	477
Other	616	502	672
Total	16,005	26,260	28,946

[r] Revised.

Table 8.—Consumption, stocks, receipts, shipments and/or sales of purchased secondary nickel in 1973, by use [1]

(Short tons)

Use	Receipts	Consumption	Shipments or sales	Stocks end of year
Steel:				
Stainless and heat-resisting	32,229	30,336	1,351	3,514
Alloy (excludes stainless)	1,249	1,101	38	296
Superalloys	--	(2)	(2)	(2)
Nickel-copper and copper-nickel alloys	865	882	6	464
Permanent magnet alloys	W	W	--	W
Other nickel and nickel alloys	1,346	1,320	--	165
Cast irons	96	114	--	20
Electroplating	W	W	--	W
Chemicals and chemical uses	W	W	--	--
Other uses	113	124	(2)	28
Total reported by companies canvassed and estimated	35,898	33,877	1,395	4,487

W Withheld to avoid disclosing individual confidential data; data on permanent magnet alloys, electroplating, and chemicals and chemical uses included with other uses.
[1] Data should not be considered as annual owing to its incompleteness.
[2] Less than 1 unit.

PRICES

The producer price for electrolytic nickel was unchanged at $1.53 per pound during the year. Prices were unchanged for domestically produced nickel in ferronickel in 1973, the quoted price was $1.38 per pound. The price of foreign produced ferronickel was increased on July 9 by NC Trading Co., the sales agent for SLN, by 6 to 7 cents per pound. The new prices were FN4, $1.43 per pound nickel content; FN3, $1.47 per pound nickel content; and FNC, $1.45 per pound nickel content. Falconbridge Nickel Mines Ltd. increased the price of ferronickel 7 cents per pound to $1.46 effective July 13. Inco, increased prices of nickel oxide sinter-90 to $1.43 per pound nickel content, and nickel oxide sinter-75 to $1.40 per pound nickel content, effective July 20. The new Inco price was equivalent to those quoted for SLN ferronickel, recognizing the iron value in ferronickel. These price changes for nickel produced in foreign countries narrowed the differential between prices quoted for pure nickel and that quoted for nickel in ferronickel and in other forms of nickel suited for steelmaking.

FOREIGN TRADE

U.S. exports of nickel, nickel alloy, and catalysts were 20% more than those of 1972. Exports of nickel waste and scrap decreased 26% from that of 1972.

Canada continued to be the principal supplier of nickel to the United States in 1973 and accounted for 63% of the total nickel imported for consumption. Nevertheless, Canada's portion of the total imports was 10 percentage points less than in 1972. The Dominican Republic nearly replaced Norway as the second most important source of imported nickel. The strong influx of ferronickel that began in 1972 continued through 1973; imports of ferronickel more than doubled. The Dominican Republic and New Caledonia were responsible for the major portion of ferronickel imported into the United States in 1973. The total of nickel in all forms imported for consumption in 1973 was 10% more than was imported in 1972.

Table 9.—U.S. exports of nickel and nickel alloy products, by class

Class	1971		1972		1973	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Unwrought	4,287	$8,614	2,178	$6,469	3,764	$10,549
Bars, rods, angles, shapes sections	4,904	16,828	2,140	9,038	1,949	9,647
Plates, sheets, strip	3,351	14,675	3,455	16,625	3,827	20,470
Anodes	334	1,147	481	1,490	752	2,400
Wire	643	3,269	553	2,638	697	3,818
Powder and flakes	696	2,754	341	2,800	514	4,813
Foil	7	41	11	28	11	61
Catalysts	3,740	10,018	2,573	6,794	2,478	6,584
Tubes, pipes, blanks, fittings therefore, hollow bars	2,134	9,985	1,499	8,831	1,825	9,815
Waste and scrap	6,047	7,239	8,440	9,055	6,253	7,646
Total	26,143	74,570	21,671	63,768	22,070	75,803

Table 10.—U.S. imports for consumption of nickel products, by class

Class	1971		1972		1973	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Ore	13,173	$297	258	$6	8,207	$190
Unwrought	100,531	259,931	125,364	330,825	120,083	343,494
Oxide and oxide sinter	5,769	11,604	5,988	12,038	6,301	13,466
Slurry [1]	32,944	73,656	28,222	57,085	38,729	81,814
Bars, plates, sheets, anodes	79	302	198	683	320	1,156
Rods and wire	768	3,642	694	2,964	790	3,959
Shapes, sections, angles	([2])	1	1	7	([2])	1
Pipes, tubes, fittings	10	47	63	314	570	2,579
Powder	1	3	4,499	14,109	7,196	22,770
Flakes	2,708	8,234	331	909	95	297
Waste and scrap	1,336	1,896	2,306	3,517	2,642	3,906
Ferronickel	26,233	16,986	51,741	35,857	89,780	70,532
Total (gross weight)	183,552	376,599	219,665	458,314	274,713	544,164
Nickel content (estimated)	142,183	XX	173,870	XX	191,073	XX

XX Not applicable.
[1] Nickel-containing material in slurry, or any form derived from ore by chemical, physical, or any other means, and requiring further processing to recover nickel or other metals.
[2] Less than ½ unit.

Table 11.—U.S. imports for consumption of new nickel products [1], by country

(Short tons)

Country	Metal		Powder and flakes		Oxide and oxide sinter		Slurry and other [2]			
	1972	1973	1972	1973	1972	1973	1972		1973	
	(gross weight)		(gross weight)		(gross weight)		Gross weight	Nickel content	Gross weight	Nickel content
Australia	487	1,974	195	2,265	--	--	--	--	--	--
Canada	97,250	83,974	1,487	889	5,967	6,227	28,188	22,792	38,626	30,824
Dominican Republic	--	406	--	--	--	--	--	--	--	--
Finland	55	97	2	--	--	--	--	--	--	--
France	558	1,312	249	2	15	40	(3)	(3)	--	--
Germany, West	561	71	11	1	--	--	--	--	--	--
Mozambique	67	149	--	--	--	--	--	--	--	--
Netherlands	166	15	--	20	--	(3)	11	3	--	--
Norway	17,295	14,515	--	48	--	--	--	--	--	--
Rhodesia, Southern	1,801	3,944	--	--	--	--	--	--	--	--
South Africa, Republic of	2,791	3,037	215	330	--	--	--	--	--	--
Sweden	(3)	61	--	(3)	--	--	--	--	--	--
Switzerland	--	56	--	1	--	--	--	--	--	--
U.S.S.R.	94	3,264	6	--	--	--	--	--	--	--
United Kingdom	4,135	7,208	2,645	3,715	--	14	23	21	70	47
Uruguay	70	--	--	--	--	--	--	--	--	--
Other	34	--	20	20	6	20	--	--	33	6
Total	125,364	120,083	4,830	7,291	5,988	6,301	28,222	22,816	38,729	30,877

[1] Ore, short tons: 1972—258; Canada 52, Colombia 70, Philippines 136; 1973, Australia 113, Colombia 8,094, France less than 1 short ton.
[2] Nickel-containing materials in slurry, or any form derived from ore by chemical, physical, or any other means, and requiring further processing to recover nickel or other metals.
[3] Less than ½ unit.

WORLD REVIEW

Australia.—At midyear, six nickel mines were operating in Australia. The Redross nickel mining project in Western Australia was reopened in 1973 by the partnership of Anaconda Inc., the Australian subsidiary of The Anaconda Company of the United States, Conzinc Riotinto of Australia, Ltd. (CRA), and New Broken Hill Consolidated Ltd. (NBHC). Anaconda held a 60% interest, CRA 26⅔%, and NBHC 13⅓%. Full production, rated at 10 million pounds per year of nickel concentrate, was expected by 1974 with reserves adequate for 7 years of operation at this rate. Initially the ore was to be toll-milled at Western Mining's Kalgoorlie concentrator. The concentrate was to be shipped from the port of Esperance to Sherritt Gordon Mines Ltd.'s refinery at Fort Saskatchewan, Canada, for toll-refining. At yearend, the partnership was conducting economic feasibility studies to determine if a nickel smelter, using Anaconda's Arbiter process, should be built in Western Australia.

There were only two significant new nickel finds in Australia in 1973. One of the finds was at Forrestania, 170 miles southwest of Kambalda. The discovery was being explored by American Metals Climax Inc., American Oil Co., a subsidiary of Standard Oil Co. (Indiana), and several small Australian companies. The other discovery was near the Pilbara Coast at Sherlock Bay. Texas Gulf, Inc., was exploring the find. Preliminary estimates by company officials were 75 million tons of ore averaging 0.5% nickel.[2]

Western Mining Corporation Ltd. dedicated its new flash smelter at Kalgoorlie in April 1973. The furnace at Kalgoorlie was blown in on December 5, 1972, and had a rated capacity of 25 tons of nickel concentrate per hour utilizing the Outokumpu Oy process. Prior to smelting, the concentrate assayed 11% to 13% nickel and 1.02% to 1.20% copper. Smelting produced a high-grade matte containing approximately 75% nickel plus copper. Western

[2] Financial Times. Capital Nickel Goes Into Production. No. 26,146, Aug. 28, 1973, p. 26.

Table 12.—Nickel: World mine production[1], by country

(Short tons)

Country[2]	1971	1972	1973[p]
Australia (content of concentrate)	[r] 39,185	39,442	44,163
Brazil (content of ore)[e]	3,500	3,500	3,500
Burma (content of speiss)	26	29	[e] 30
Canada[3]	294,342	258,987	268,908
Cuba (content of oxide and sulfide)[e]	39,000	[r] 35,000	35,000
Dominican Republic	220	19,200	[e] 26,000
Finland:			
Content of concentrate	3,867	5,687	6,400
Content of nickel sulfate	136	211	[e] 220
Greece (recoverable content of ore)	11,655	12,500	13,900
Indonesia (content of ore)[4]	21,800	24,738	22,946
Mexico (content of ore)	[e] 55	[e] 55	--
Morocco (content of nickel ore and cobalt ore)	110	220	[e] 330
New Caledonia (recoverable)[5]	[r] 111,636	98,015	109,005
Norway (content of concentrate)	397	425	[e] 440
Poland (content of ore)[e]	2,200	2,200	2,200
Rhodesia, Southern (content of concentrate)[e]	12,800	13,200	13,200
South Africa, Republic of	[r] 14,062	12,849	[e] 11,500
U.S.S.R. (content of ore)[e]	130,000	140,000	150,000
United States (content of ore shipped)	17,036	16,864	18,272
Total	[r] 702,027	683,122	726,014

[e] Estimate. [p] Preliminary. [r] Revised.
[1] Insofar as possible, this table represents mine production of nickel; where data relate to some more highly processed form, the figures given have been used in lieu of unreported actual mine output to provide some indication of the magnitude of mine output and are so noted parenthetically following the country name.
[2] In addition to the countries listed, Albania and East Germany also produce nickel from mines, but available information is inadequate to make reliable estimates of output levels.
[3] Refined nickel and nickel content of oxides and salts produced, plus recoverable nickel in exported mattes and speiss.
[4] Includes a small amount of cobalt not recovered separately.
[5] Nickel-cobalt content of metallurgical plant products, plus recoverable nickel-cobalt in exported ores.

Table 13.—Nickel: World smelter production [1], by country

(Short tons)

Country [2]	1971	1972	1973 p
Australia	15,400	18,200	36,700
Brazil [3]	r 2,800	3,100	e 3,100
Canada [3]	r 182,200	145,200	178,400
Cuba e [3]	35,000	r 35,000	35,000
Czechoslovakia e	900	900	900
Dominican Republic [4]	374	19,200	e 26,000
Finland	4,288	6,016	6,400
France	9,486	14,409	e 12,500
Germany, West	220	220	e 220
Greece	11,655	12,500	13,900
Japan [5]	r 113,100	87,600	e 88,000
New Caledonia [6]	r 49,614	61,983	63,091
Norway	r 46,043	47,739	47,075
Poland e	2,200	r 1,700	1,700
Rhodesia, Southern e [3]	r 11,000	r 11,000	11,000
South Africa, Republic of [3]	r 11,000	11,000	11,000
United Kingdom	42,700	35,200	e 40,800
U.S.S.R. e	130,000	140,000	150,000
United States:			
Byproduct of metal refining	2,581	2,505	958
Recovery from domestic ore	13,073	13,226	12,937
Total	r 683,634	666,698	739,681

e Estimate. p Preliminary. r Revised.
[1] Refined nickel plus nickel content of ferronickel produced from concentrates unless otherwise specified.
[2] In addition to the countries listed, East Germany and North Korea are believed to produce metallic nickel and/or ferronickel, but information is inadequate to make reliable estimates of output levels.
[3] Includes nickel content of nickel oxide and nickel fonte in addition to metallic nickel and ferronickel.
[4] Nickel content of ferronickel only (no refined nickel is produced).
[5] Includes electrolytic nickel as follows, in short tons: 1971—17,077; 1972—18,189; 1973—23,249; the difference between these figures and the listed total is the nickel content of ferronickel, nickel oxide and nickel fonte.
[6] Nickel-cobalt content of ferronickel and matte.

Mining produces over 70 million pounds of nickel annually, or nearly 8% of the free world's output. The company marketed nickel in the United States, the United Kingdom, other European countries, India, and Japan. In addition to Western Mining's nickel production from the Kambalda region, the company was expanding its exploration activities across Lake Lefroy into the Paris-St. Ives region. At yearend, Western Mining had increased its proven reserves in the Kambalda and St. Ives region from 22.7 million tons containing 3.29% nickel to 24 million tons containing 3.24% nickel.

Development of the Greenvale nickeliferous laterite deposit by Freeport Queensland Nickel Inc., a wholly owned subsidiary of Freeport Minerals Co. of the United States, and Metals Exploration N.L. of Australia continued on schedule during 1973. Early in 1973 a contract was let for the construction of the town of Greenvale in Queensland. At the same time, the treatment plant foundation was poured at Yabulu, near the coast, 140 miles from the mine site. Stripping of mine overburden also began in early 1973 as did construction of a 140-mile-long railway connecting the mine at Greenvale with the Yabulu treatment plant. The plant was designed to treat a million dry tons of ore annually and produce over 50 million pounds of nickel. The hydrometallurgical process was based on ammoniacal leaching of pyrometallurgical reduced ore. Western Europe was to receive the major portion of output; Japan was to receive about 18%.

A joint venture between Poseidon N.L., Western Mining Corporation, Ltd. and Sherritt Gordon Mines, Ltd., of Canada to develop the Windarra nickel deposit in Western Australia gathered momentum in 1973. Ore production was to begin in August 1973, but was unconfirmed at yearend. Nevertheless, Poseidon reportedly awarded, in late 1973, a contract to Ruwolt Pty. Ltd. to supply mineral processing equipment for the Mt. Windarra project. The equipment, valued at $1.4 million, included an apron feeder, a Symons cone crusher, 6 grinding mills, and 13 Paramount vibrating feeders.

Technical feasibility of mining the Agnew nickel deposit in Western Australia was confirmed in 1973. Exploration activities were conducted by Selection Trust Ltd. and Consolidated African Selection Trust Ltd. At yearend, indicated reserves were 40 million tons of ore averaging 2% nickel. Australian participation in the development of the Agnew deposit, through Selcast Exploration Ltd., was 18%.

At yearend, the Australian Government was preparing to reveal a new national petroleum and minerals authority bill.[3] The bill would foster a new Government policy toward insuring maximum Australian ownership of the nation's mineral wealth. Foreign ownership of Australian mineral wealth had been estimated at 62%. The immediate and long-range effects of the bill, should it become law, on foreign investments, mineral exploration, and mining in Australia were uncertain at yearend.

Botswana.—BCL expected to begin mining the Selebi-Pikwe copper-nickel deposits early in 1974. Ore concentrating and smelting facilities reportedly were completed in 1973. The matte produced from the smelting process was to be refined at Amax Nickel's rehabilitated plant in Louisiana, United States. Considerable exploration for copper-nickel deposits was conducted during 1973 with several new discoveries being evaluated at yearend.

Canada.—Canada remained the world's leading producer of nickel accounting for nearly 37% of the total world mine output. Nickel production was reported as 268,908 tons of contained metal, a 3.8% increase over that produced in 1972. The principal producers of nickel in Canada remained Inco, Falconbridge Nickel Mines Ltd., and Sherritt Gordon Mines Ltd.

Inco mined a total of 19.7 million dry tons of ore having an average nickel content of 1.4% in 1973, compared with 19.2 million tons having an average nickel content of 1.3% in 1972. Company officials reported that the higher average grade of ore mined in 1973 over that of 1972 was a result of improved grade control in mining operations and increased production from mines having higher grade ore. In 1973 Inco had 16 mines in full or partial production, 13 in Ontario and 3 in Manitoba. Three mines remained on standby status in 1973. They were the Totten and Murray mines in Ontario and the Soaba in Manitoba. The company expected to reactivate the Crean Hill mine and the Leback West mine early in 1974. Inco officially opened its Copper Cliff nickel refinery in October 1973. The plant was expected to reach its full designed capacity of 125 million pounds of nickel per year in pellet and powder forms by mid-1974. The Copper Cliff facility was the only plant in North America producing nickel pellets.

Falconbridge and Sherritt Gordon remained the No. 2 and No. 3 producers, respectively, of nickel in Canada in 1973. However, Falconbridge, as a result of problems with research and equipment deliveries, coupled with the failure of its nickel-iron pellet refinery in 1972, had to schedule changes in its air pollution abatement plans for the Sudbury area of Northern Ontario. Falconbridge's program called for major revisions to its smelting process and other facilities at a cost estimated at more than $40 million. The revised process was designed to improve working conditions in the plants and bring about a significant reduction in sulfur dioxide emissions to the atmosphere. The revisions were to incorporate fluid-bed roasting, electric smelting, and treatment facilities for roaster gases. These changes would eliminate the need for sintering, which is a source of sulfur dioxide in the existing smelter complex and process, and would replace existing blast furnace operations. According to company officials, production from the processing complex will not be affected during the conversion nor will the capacity of the plant be increased when the revisions are completed. Giant Mascot Mines Ltd., made its first shipment of nickel concentrate from its Hope mine to the Sherritt Gordon refinery near Edmonton in 1973. Giant Mascot was to supply Sherritt Gordon with a nickel concentrate grading 10% to 12% nickel and 2% copper. Exploration to maintain and expand existing ore reserves was begun in 1973.

The principal Canadian nickel producers and their 1973 production, sales or deliv-

[3] Engineering and Mining Journal. Changes in Australia's Minerals Policy to be Revealed by Labor Government. V. 175, No. 1, January 1974, p. 40.

eries to customers as given in their annual report to stockholders were as follows:

Company	Type of operation	Thousand pounds
International Nickel Co. of Canada, Ltd	Delivery	517,000
Falconbridge Nickel Mines Ltd	do	99,408
Sherritt Gordon Mines Ltd	Sales	17,499

Early in 1973 officials of Boliden A.B. of Stockholm, Sweden, announced that the company would invest a second $1 million in a joint venture with Great Lakes Nickel, Ltd., of Toronto, Ontario, to develop the Great Lakes nickel-copper mining property near Thunder Bay, Ontario. The investment was used to complete work on Boliden's feasibility report. The report completed in July 1973, recommended construction of a mine and mill with an initial designed capacity of 1.8 million tons per year. Capital costs of this initial stage were calculated at $31.2 million, with expected startup by mid-1975. The company also recommended that the deposit be mined by the underground room and pillar method in order to obtain minimum dilution and to provide the lowest development and production costs. A two-stage autogenous grinding system and flotation process would be used to separate nickel and copper concentrates. Indicated ore reserves were confirmed at 32.8 million tons averaging 0.36% copper and 0.20% nickel. Potential reserves included an additional 40 million tons of ore. Boliden was to secure markets for the concentrate.

The fuel shortage that occurred late in 1973 required major nickel producers to review their energy requirements. Canadian production was not adversely affected by fuel shortages.[4] Canada not only has large reserves of petroleum but also relies heavily on hydroelectric power for the production of nickel.

Colombia.—Negotiations were carried out during 1973 between the Colombian Nickel Co. (CONICOL) and the Instituto de Fomento Industrial (IFI) of Colombia in an attempt to resolve problem areas that existed between the various parties. Estimates for start up, should all problems be resolved, were from 40 to 45 months.

Cuba.—Cuba rearranged its sales price on nickel to the U.S.S.R. to $2.265 per pound of contained nickel as part of the recent Cuban-U.S.S.R. plan to renovate and modernize both the Moa Bay and Nicaro nickel facilities and develop the new Punta Gorda nickel deposit. The new price was to prevail for a period of 7 years (1973–80). The price was estimated to be about 90 cents per pound more than Inco's price for similar quality material. Work on renovating the Moa Bay and Nicaro nickel facilities was to begin in 1973. Government officials were hopeful that Cuban production would ultimately reach 126,000 tons of nickel per year or an increase of 90,000 tons.

Dominican Republic.—Falconbridge Dominicana C. por A. operated its plant at Bonao at about 87% of designed capacity of 63 million pounds per year of nickel in ferronickel. The plant's designed throughput was not to be sustained until completion of the warranty inspection of three turbine generators, installation of improved metal handling facilities, and modifications to the ore preparation circuit. Falconbridge exported approximately 70,000 tons of nickel in 1973, valued at about $75 million. Nearly 50% of the exports went to Europe, 40% to the United States, and the balance to Japan. Under the company's contract it was obligated to explore an area of 78,000 hectares for additional nickel. The new exploration was to begin in early 1974. At yearend 1972, reserves were reported to be 70.8 million dry tons grading 1.6% nickel.

Finland.—Finland's total productive capacity for nickel ore was increased early in 1972 when the open pit at Keretti, Vuonos became operational. Underground production from the Vuonos nickel ore body began in November 1973. The deposit was discovered in 1965 and developed for initial production in 1972 at a cost of about $27.5 million. Plans were to mine and process 1.6 to 2.0 million tons per year of nickel ore from the two zones. To date the Vuonos operation has shown an efficiency of 80% in recovering nickel contained in a 6% nickel concentrate.

The nickel refining process developed by Outokumpu was a pioneering effort in hydrometallurgy and electrowinning techniques. The nickel refining section of the

[4] International Nickel Co. of Canada, Ltd. 1973 Annual Report. P. 12.

Harjavalta complex was first established as a 3,300-ton-per-year plant in 1959, its 1973 capacity was 11,000 tons per year of electrolytic nickel.

Greece.—Greece's only nickel producer, Société Minière et Métallurgique de Larymna S.A. (LARCO), produced approximately 15,000 tons of nickel in 60,000 tons of ferronickel in 1973. LARCO mined nickel ore from a laterite deposit at Larymna, 71 miles northeast of Athens, Greece. The ore contained 1% to 1.6% nickel. A larger but lower grade lateritic ore body with 1.1% nickel was located on the island of Euboea. Total reserves were estimated at over 240 million tons. LARCO's capacity was to be expanded to 80 million pounds of nickel per year at a later date if warranted by future demand. The company commissioned a new (third) rotary kiln for production of ferronickel at the Larymna plant early in 1973. LARCO's open pit mines on the island of Euboea were being expanded during the year. Studies were being conducted by the company in 1973 to determine the feasibility of converting the Aghios Ioannis mines from underground to open pit. Currently, about 80% of the ore treated comes from Euboea and 20% from the Aghios Ioannis deposit. LARCO has been able to lower the arsenic content of its ferronickel by using larger portions of the virtually arsenic-free ore from Euboea.

Intercontinental Mining and Abrasives, Inc. was constructing a nickel refinery near Lake Ionina. The refinery, costing $30 million, was to produce 12 million pounds of ferronickel per year. The project was to be completed by 1974.

Guatemala.—Exploraciones y Explotaciones Mineras Izabal S.A. (EXMIBAL), completed negotiations in 1973 with the Guatemalan Government for the development of nickel deposits in the country. EXMIBAL owned a lateritic nickel deposit near Lake Izabal. Contracts were let to McKee Latin America, Inc., for designing and constructing the processing plant and related facilities, and to the Montreal Engineering Co., Ltd., for designing the powerplant. Construction began in 1973 on the first phase of the project. The plant was to be commissioned by the end of 1976. Annual production was to be 25 million pounds of nickel in the form of 75% nickel matte. Inco, the principal owner of EXMIBAL, secured loans during the year of $15 million from the World Bank affiliate International Corp. and $13.5 million from the U.S. Export-Import Bank. Total cost of the project was estimated to be $90 million.

Indonesia.—A decision to proceed with the first phase of the lateritic mining and processing project of P.T. International Nickel Indonesia, a wholly owned subsidiary of Inco, was announced in April 1973. At yearend, construction had begun, and contracts were awarded to the Dravo Corp. for general engineering and construction work, to the Montreal Engineering Co., Ltd., for designing the powerplant, and to International Design Consultants of Jakarta for designing the town site in Sulawesi. The plant was to become operational in 1976. Proposed output of nickel, as 75% nickel matte, was increased in 1973 from 30 million to approximately 35 million pounds per year. Company officials estimated that reserves were sufficient to permit production to be increased to more than 100 million pounds of nickel annually at a later date.

The Indonesian Mining Corp., P.N. Aneka Tambang (ANEKA), continued construction of a smelter at Pomalaa, designed to produce 4,000 tons of nickel per year in ferronickel by late 1974 or early 1975. Japan was to import the entire output. In other developments, the Indonesian Nickel Development Co. of Japan began surveying nickel ore deposits in the Halmahera area of the Molucca Islands late in 1973. Preliminary estimates indicated 240 million wet tons of lateritic ore with a nickel content ranging from 1.3% to 1.4%. Company officials expected the survey to take approximately 1 year and that a comprehensive development plan would be drafted by 1975. To date, the largest planned Indonesian nickel operation was that of P.T. Pacific Nickel Indonesia. The company planned to produce 100 million pounds of nickel per year from deposits on Gag Island, Irian Barat. At yearend, pilot plant testing of the ore had been completed, and feasibility studies were being made by Sherritt Gordon, the prime company in this undertaking. Other companies involved in this venture were the United States Steel Corp., Newmont Mining Corp., and Koninklijke Nederlandsche Hoogovens en Staalfabrieken, N.V. The preliminary project completion date was given as 1975. However, at yearend, financing arrangements had not been completed.

New Caledonia.—Production of nickel ore in New Caledonia in 1973 was 11% greater than that produced in 1972. Nickel smelter production increased 2% in 1973 over that of 1972. More specifically, ferronickel output decreased by 1% and matte production increased by 7% compared with that of 1972. With a settlement of price differences between Japanese consumers and the independent mining industry in New Caledonia, exports of nickel ore to Japan increased 26% in 1973 compared with exports in 1972.

New Caledonia's principal nickel producer Société le Nickel, S.A. (SLN) experienced considerable difficulties in 1973. Major problem areas for SLN Caledonia were export taxes, averaging 11% ad valorem, and revaluing of the franc by 20% against the dollar in 1973. At yearend, the French Government had proposed that the New Caledonian administration reduce the tax burden in 1974 on SLN by about $13 million. An additional proposal by the French Government was that the New Caledonian Power Utility (ENERCAL) buy SLN's power station for approximately $45 million. At yearend Kaiser Aluminum & Chemical Corp. announced an agreement whereby SLN would purchase Kaiser's 50% interest in New Caledonian Co. This would give SLN full ownership. The transaction was contingent upon necessary Government approvals and actions. SLN installed its third 33,000-kilowatt furnace at Domiambo at midyear. The new addition increased SLN's smelter capacity to about 85,000 tons per year of nickel contained in ferronickel and matte. A new mine was commissioned at Si Reiss II during 1973. When the new mine reaches capacity, the mining complex will be able to produce 2.4 million tons of ore per year.

A proposal submitted February 1973, by Inco for mining a low-grade lateritic ore body near Goro on the island's southernmost extremity had not been acted upon by the French at yearend. If approved, Inco hoped to produce approximately 20,000 tons per year of nickel and 1,400 tons per year of cobalt by 1978, at an estimated capital investment of $275 million. The company planned to more than double the output of nickel to 45,000 tons per year at a later date. The project was dependent upon Inco acquiring mining rights to the Goro deposits presently held by the French Bureau de Recherches Géologiques et Minières. Another project involving the Goro deposit was submitted by Freeport Minerals Co. of the United States and Société Nationale des Pétroles d'Aquitaine of France.

A third project still active at yearend was the Compagnie Française d'Entreprises Minères Métallurgiques et d'Investissements (COFREMMI), Pechiney Ugine Kuhlmann, Granges Co. proposal to develop garneritic ores at Tiebaghi in the northwestern part of New Caledonia. COFREMMI, a Patiño subsidiary, was to operate the mine, selling the ore at a profit to the smelter, which was to be owned by all three partners. Near yearend Pechiney and Granges withdrew from the Tiebaghi project. Nevertheless, COFREMMI indicated it planned to proceed on its own. Reportedly, Government approval had been received and financing was being arranged at yearend. Tentatively, the project was slated for completion by 1975 and would have a capacity of 36,000 tons per year of nickel in ferronickel.

Philippines.—Construction of the Nonoc nickel refinery by Marinduque Mining & Industrial Corp. made significant progress in 1973 with engineering and equipment procurements being completed. During the year, pier facilities for oceangoing tankers and a tank farm were completed, a ¾-mile long air strip became operational, all-weather roads completed, and housing for senior and junior staff members neared completion. Also nearing completion at yearend was a dam on the Sabang River in northern Dinagat Island designed to provide water and standby power for the Nonoc operation. The first mining block was developed in 1973. Nickel production was expected to begin in August 1974. With a designed capacity of 3.8 million dry tons of ore annually, the refinery will make the Philippines the largest pure nickel producer in Southeast Asia. The Sherritt Gordon ammonium carbonate leach process will be used to extract nickel from the lateritic ore.

The Philippine Government, which until

this year had sought to defer new nickel ventures until the Marinduque project was onstream, reversed itself and gave the go ahead to two potentially important nickel projects. One project, a joint venture between Atlas Consolidated Mining Development Corp. and Mitsubishi Metal Mining Co. Ltd. of Japan to develop laterite deposits on Palawan and build a 35-million-pound-per-year nickel refinery was expected to proceed. Company officials of Atlas stated that pilot plant tests, conducted by Freeport Minerals Co., had confirmed the technical feasibility of utilizing the Freeport process in treatment of the Palawan ore. The second project was to exploit lateritic nickel deposits in northern Luzon. The partners in this venture were New Frontier Mines and Hochmetals of Panama. Annual capacity of the New Frontier operation was to be 33 million pounds of nickel.

In 1973 the Philippine Government altered its export laws covering nickel to permit the shipment of beneficiated ores rather than refined metal. To date, there have been five proposals submitted to the Board of Investments for ore exporting operations. Among companies interested in the recent Government ruling was Pacific Metals Co., Ltd., which agreed to purchase from Universal Oil Products Co. its 40% interest in Rio Tuba Nickel Mining Corp. of the Philippines. Exploration of Rio Tuba deposit has confirmed 32 million dry tons of ore with an average grade of 2.2% nickel. Total ore reserves were estimated at 81 million dry tons averaging about 1.6% nickel. The higher grade nickel ore was suitable for direct shipment to nickel smelters in Japan where Pacific Metals, a subsidiary of Nippon Steel Co., operated plants that produce ferronickel alloys.

TECHNOLOGY

Based on the number of reports and patents issued in 1973, nickel research has slowed somewhat during the past few years. Nevertheless, research can be expected to increase as the need for cryogenic storage vessels and energy related uses grow. Scientists at Bureau of Mines laboratories continued their investigations on methods of recovering nickel and copper from the Duluth gabbro of Minnesota. A reduction-roast, magnetic-separation process, as applied to gabbro flotation concentrate containing 0.9% nickel and 4.2% copper, reportedly yielded more than 95% nickel and copper in a magnetic concentrate.

The Bureau's scientists filed an invention report in 1973 in which they described an efficient extraction treatment process for low-grade lateritic ores. The oxide ore was selectively reduced and leached in an ammonia-ammonium sulfate system to recover 90% of the nickel and more than 80% of the cobalt. The nickel was selectively removed by liquid ion extraction and subsequently recovered by electrolysis; cobalt was precipitated from the leach solution as cobalt sulfide.

A new process for the recovery of nickel and cobalt from limonites by aqueous chlorination in sea water was described in a joint paper by scientists of Dartmouth College, Hanover, N.H. and Delft University of Technology, Delft, the Netherlands.[5] The process was based on selective reduction of the ore pyrometallurgically and aqueous chlorination in sea water. Reportedly, advantages gained from the process were as follows: High recovery of nickel and cobalt, rapid dissolution rates, and the use of saline in place of fresh water. Scientists at Republic Steel Corp. reported on a new process for extracting nickel from laterites, silicates, and sulfides utilizing hydrothermal sulphidization and oxidation steps followed by high-temperature cementation-in-pulp. Reportedly, the process was adaptable to iron-rich laterites, magnesium-rich silicates, and sulfide ores. Company officials reported yield recoveries consistently above 90%.[6]

The ad hoc interdisciplinary panel of experts formed by the Committee of Biological Effects of Atmospheric Pollutants, Division of Medical Sciences of the National Research Council to study nickel as a possible hazardous pollutant and toxic material finished its work. Its report was still being processed at yearend.

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[5] Roorda, H. J., and P. E. Queneau. Recovery of Nickel and Cobalt From Limonites by Aqueous Chlorination in Sea Water. Inst. Min. and Met. (Sec. C), v. 182, No. 799, June 1973, pp. C79-C87.

[6] Engineering and Mining Journal. Republic's New Nickel Process Digests Laterites, Silicates, or Sulphides. V. 174, No. 5, May 1973, pp. 80-81.

Numerous patents were issued during 1973 on mining deep sea manganese nodules and subsequent recovery of nickel. In general, recovery techniques included both pyrometallurgy and hydrometallurgy to extract the metal values from nodules. Officials of Inco reported that the company's Ocean Mining Development group was continuing to investigate the feasibility of recovering nickel-bearing nodules from the ocean floor.[7] No details regarding the investigations were reported.

The Canadian National Research Council (NRC) in conjunction with its studies relating to the use of hydrogen as a fuel, announced a program directed at developing storage canisters containing metals as sponges. Alloys of nickel were among a list of metals being studied by NRC scientists in 1973. Inco metallurgists developed a copper-nickel-zinc-manganese spring alloy (IN-629) particularly suited for use in relay leaf springs and connectors. The alloy should find applications in the electrical and electronics industries, particularly in telecommuncations where ease of forming, moderate strength with high ductility, and good corrosion resistance are needed.[8] Inco metallurgists also introduced a powder metallurgy steel having excellent physical properties and not requiring heat treatment. The 2% nickel steel (IN-861) in the sintered condition had tensile strengths in the range of 70,000 to 90,000 pounds per square inch. Possible uses for the new nickel steel powder reportedly would be in parts presently cast and machined and as a substitute for other powder metallurgy alloy mixes.[9]

Officials of Latrobe Steel Co. of Latrobe, Pa., announced the development of a new high-temperature, high-strength (super) alloy composed principally of nickel, cobalt, and chromium. Reportedly, the alloy will be suited for jet engine components and high-stress parts as well as in marine and petrochemical machinery and equipment. The alloy was reported to have high corrosion resistance as well as high resistance to crevice corrosion and stress corrosion cracking in hostile environments. The alloy was designated Multiphase MP159 and contained 25.5% nickel, 35.5% cobalt, 19% chromium, 9% iron, 7% molybdenum, 3% titanium, 0.6% columbium and 0.2% aluminum.[10]

National Aeronautics and Space Administration (NASA) scientists reported the development of a nickel base (chromium free) superalloy having twice the strength of the strongest previously available cast nickel base alloy. Designated WAX-20, the alloy was composed of 17% to 20% tungsten, 6% to 7% aluminum, 1.4% to 1.6% zirconium, 0.1% to 0.2% carbon, with the balance nickel. The alloys melting point was reported as 2,375° F with a tensile strength of 20,000 pounds per square inch at 2,200° F.[11]

NASA scientists at the Lewis Research Center's Energy Conversion and Materials Science Section announced the development of a photographic film and processing procedure utilizing nickel in place of silver. The film, used in X-ray and electron beam photography, was insensitive to light. The image was reported to be comparable with those produced by the common silver-based photographic process.[12] General Electric engineers reported on the use of carbonyl nickel powder in the company's first fast-recharge, nickel-cadmium battery. The new batteries were capable of being recharged in less than 15 minutes at low cost compared with nearly 2 hours required by more costly and exotic cells used in space work. Reportedly, the nickel carbonyl permitted the formation of porous nickel battery plates, which was essential for controlling rapid recharging. The nickel-cadmium cells have a long discharge-recharge cycle life and remain viable when not in use. Company officials expect the cells to find use in home tools, two-way radios, medical instruments, photographic equipment, and standby power for lighting.[13]

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[7] International Nickel Co. of Canada Ltd. 1973 Annual Report. P. 15.

[8] Ward, D. M., B. J. Helliwell, and P. J. Penrice. Development of a New Cu-Ni-Zn-Mn Spring Alloy—IN-629. Metallurgia and Metal Forming, v. 40, No. 10, October 1973, pp. 319-324.

[9] Canadian Mining and Metallurgical Bulletin. New P/M Alloy. V. 66, No. 733, May 1973, p. 113.

[10] American Metal Market. Latrobe Claims New Strong, Corrosion-Resistant Alloy. V. 80, No. 244, Dec. 18, 1973, p. 16.

[11] Foundry. New High Temperature Superalloy. V. 101, No. 10, October 1973, p. 28.

[12] Industrial Research. TR100 Photographic and Optical Equipment. V. 15, No. 10, Sept. 18, 1973, p. 42.

[13] Ruth, J. P. Carbonyl Nickel Powder Plays Key Role in GE's New Rapid Recharge Battery. Am. Metal Market, v. 80, No. 92, May 10, 1973, pp. 2, 10.

Nitrogen

By William F. Keyes[1]

Production of fixed nitrogen (that is nitrogen in compounds) increased 2% in 1973. Production of elemental nitrogen continued to grow rapidly, increasing by 17% in 1973. Exports of fixed nitrogen increased 15% during the period and net exports increased from 363,000 to 539,000 short tons of contained nitrogen. Domestic ammonia plants produced at about 95% of capacity during the year and estimated consumption increased 5%. Plans to construct one ammonia plant were announced.

Table 1.—Salient nitrogen statistics
(Thousand short tons of contained nitrogen)

	1969	1970	1971	1972	1973 p
United States:					
Production as ammonia	r 10,678	r 11,531	r 12,107	12,651	12,870
Production as nitrogen gas	4,807	5,477	6,087	7,011	8,171
Exports of nitrogen compounds [1]	1,645	1,400	999	1,310	1,506
Imports for consumption of nitrogen compounds [1]	738	942	907	947	967
Consumption [1]	r 9,953	r 10,891	r 11,903	12,333	12,980
World: Production [1]	39,556	42,747	45,357	47,398	51,500

p Preliminary. r Revised.
[1] Estimated, excludes nitrogen gas.

DOMESTIC PRODUCTION

Domestic production of anhydrous ammonia increased nearly 2% in 1973, while production of elemental nitrogen increased 17%. No new ammonia plants were brought into production during the year. Ammonia plants operated at 93% of capacity during the first 6 months of 1973 and at almost 98% of capacity during the last 6 months of 1973, according to The Fertilizer Institute.

Nitrogen is derived from air, and the chief raw material in the production of fixed nitrogen, as ammonia, was natural gas. Local shortages of natural gas caused some curtailment of ammonia production during the year. A survey by The Fertilizer Institute showed that plant days lost because of gas interruption were 605 in 1970, 773 in 1971, and 1,317 in 1972.[2] Industry estimates to the U.S. Department of Commerce in the fall of 1973 indicated a probable loss of 382,000 tons in the 1973–74 fertilizer year. Later estimates cut this figure to 231,000 tons.[3]

Agrico Chemical Co. announced plans to build an ammonia plant with a capacity of 425,000 tons annually to be located on the Verdigris River east of Tulsa, Okla. The plant was to cost $46 million, including a 600,000-ton urea ammonium nitrate solution plant. The complex was scheduled to be in operation in 1975.[4]

W. R. Grace & Co. announced that it would construct a $17 million urea production facility at its Memphis, Tenn., complex. The new facility will have a capacity of 350,000 tons per year when it reaches full production late in 1975 and will replace Grace's current 138,000-ton-per-year Memphis urea facility.[5]

CF Industries, Inc. awarded a contract for a 1,000 short-ton-per-day urea plant at Donaldsonville, La., having settled a dispute over noise pollution.[6]

[1] Physical scientist, Division of Nonmetallic Minerals—Mineral Supply.
[2] Chemical Week. V. 113, No. 8, Aug. 22, 1973, p. 41.
[3] Chemical Marketing Reporter. V. 205, No. 23, June 10, 1974, p. 4.
[4] Chemical Marketing Reporter. V. 203, No. 7, Feb. 12, 1973, p. 3.
[5] Chemical and Engineering News. V. 51, No. 30, July 23, 1973, p. 4.
[6] Nitrogen (London). No. 82, March/April 1973, p. 18.

Table 2.—Nitrogen production in the United States

(Thousand short tons of contained nitrogen)

	1969	1970	1971	1972	1973 p
Anhydrous ammonia: Synthetic plants [1]	r 10,516	r 11,384	r 11,972	12,512	12,737
Ammonia compounds, coking plants:					
Ammonia liquor	12	12	12	11	6
Ammonium sulfate	143	126	114	128	127
Ammonium phosphates	7	9	9	(2)	(2)
Total	r 10,678	r 11,531	r 12,107	12,651	12,870
Nitrogen gas [1]	4,807	5,477	6,087	7,011	8,171

p Preliminary. r Revised.
[1] Bureau of the Census Current Industrial Reports.
[2] Included with ammonium sulfate to avoid disclosing individual company data.

Table 3.—Major nitrogen compounds produced in the United States

(Thousand short tons, gross weight)

Compound	1972 r	1973 p
Acrylonitrile	557	676
Ammonium nitrate	6,881	6,952
Ammonium sulfate [1]	1,986	2,110
Ammonium phosphates	6,499	6,834
Nitric acid	7,981	7,439
Urea	3,467	3,560

p Preliminary. r Revised.
[1] Includes ammonium sulfate from coking plants.

Sources: Bureau of the Census and Tariff Commission.

The urea ammonia facility at St. Helens, Oreg., formerly operated by the Shell Chemical Co. was reopened by Reichhold Chemicals Inc. after having been closed the previous year by Shell.[7]

Phillips Petroleum Co. was expected to close its Cactus Ammonia Plant at Etter, Tex., on Nov. 1, 1973. The plant, which was one of the oldest in the United States was reportedly closed because of mounting costs of operation due to obsolete design.[8]

Plans to construct an air separation plant with an initial capacity of 270 tons per day were announced by Union Carbide Corp. The plant to be located in Garland, Tex., will produce liquid oxygen, nitrogen, and argon and should be onstream by late 1974. Cost will exceed $3 million.[9] A seventh 1,200-ton-per-day plant, to produce high-purity oxygen, nitrogen, an argon at its atmospheric gas complex in East Chicago, Ind., was also announced by Union Carbide.

An air separation facility with a capacity to produce 250 tons per day of oxygen, nitrogen, and argon was to be built by the Industrial Gases Division of Chemitron Corp. near Toledo, Ohio.[10]

Industrial Gases Division of Airco Inc. planned to construct a 400-ton-per-day air separation plant in the Albany, N.Y., area.[11]

Three new industrial gas plants were announced by Air Products & Chemicals Inc. Each will have a capacity of 300 tons daily. They will be located near Toledo, Ohio, Albany, N.Y., and Tulsa, Okla., and will have a combined liquid production capacity in excess of 325,000 tons per year.[12]

The Chemitron Corp. was constructing a $5 million air separation plant to produce 150 tons per day of oxygen, nitrogen, and argon.[13]

[7] Chemical Marketing Reporter. V. 203, No. 11, Mar. 12, 1973, p. 7.
[8] Farm Chemicals. V. 136, No. 10, October 1973, p. 54.
[9] Chemical Marketing Reporter. V. 203, No. 9, Feb. 26, 1973, p. 916.
[10] Chemical Marketing Reporter. V. 203, No. 15, Apr. 9, 1973, p. 7.
[11] Chemical Marketing Reporter. V. 203, No. 22, May 28, 1973, p. 24.
[12] Page 7 of work cited in footnote 11.
[13] Chemical Age International. V. 106, No. 2812, June 8, 1973, p. 23.

Table 4.—Domestic producers of urea

(Thousand short tons per year of urea)

Company	Location	Capacity
Agrico Chemical Co	Donaldsonville, La	200
Agway, Inc	Olean, N.Y	60
Air Products & Chemicals, Inc	Pace Jct., Fla	23
Allied Chemical Co	Geismar, La	230
Do	LaPlatte, Nebr	125
Do	South Point, Ohio	100
American Cyanamid Co	Fortier, La	145
Arkla Chemical Corp	Helena, Ark	70
Atlas Chemicals Div., Imperial Chemical Industries America, Inc	Joplin, Mo	64
Borden Chemical Co	Geismar, La	165
CF Industries, Inc	Fremont, Nebr	20
Cherokee Nitrogen, Inc	Pryor, Okla	45
Collier Carbon & Chemical Corp	Kenai, Alaska	350
Do	Brea, Calif	55
Columbia Nitrogen Corp	Augusta, Ga	30
E.I. DuPont de Nemours & Co	Belle, W. Va	40
Farmers Chemical Co	Tunis, N.C	165
Do	Tyner, Tenn	45
Farmland Industries, Inc	Lawrence, Kans	76
W. R. Grace & Co	Woodstock, Tenn	140
Hawkeye Chemical Co	Clinton, Iowa	61
Hercules, Inc	Hercules, Calif	40
Do	Louisiana, Mo	95
Kaiser Agricultural Chemicals Co	Savannah, Ga	80
Mississippi Chemical Corp	Yazoo City, Miss	153
Mobil Chemical Co	Beaumont, Tex	49
Nipak, Inc	Pryor, Okla	100
Do	Kerens, Tex	86
Olin Corp	Lake Charles, La	160
Phillips Pacific Chemical Co	Kennewick, Wash	43
Phillips Chemical Co	Beatrice, Nebr	56
Premier Petrochemical Co	Pasadena, Tex	103
Reichhold Chemicals, Inc	St. Helens, Oreg	55
Tennessee Valley Authority	Muscle Shoals, Ala	66
Terra Chemical International, Inc	Port Neal, Iowa	123
Triad Chemicals Co	Donaldsonville, La	420
USS Agri-Chemicals, Inc	Cherokee, Ala	25
Valley Nitrogen Producers, Inc	El Centro, Calif	155
Do	Helm, Calif	35
Vistron Corp	Lima, Ohio	238
Wycon Chemical Co	Cheyenne, Wyo	50
Total		4,341

Source: Harre, Edwin A. Fertilizer Trends 1973. Bulletin Y-77, National Fertilizer Development Center, Tennessee Valley Authority, Muscle Shoals, Ala. June 1974, p. 49.

CONSUMPTION AND USES

Domestic consumption of fixed nitrogen increased 647,000 tons or about 5% in 1973 compared with 1972 consumption.

Fertilizers were the major use of fixed nitrogen. Approximately three-quarters of the production was used for this purpose. Other uses of nitrogen compounds were in explosives, resins, fibers, animal feed, and plastics.

The two major uses of elemental nitrogen were to exclude air from industrial processes and, in liquid form, to provide low temperatures in food processing and scientific applications. It is estimated that 18% of elemental nitrogen use was in cryogenics.

PRICES

Prices of the major nitrogen compounds remained stable during the year until phase IV controls on fertilizers were lifted by the Cost of Living Council (COLC) in October. It was explained by the COLC that while producers could not justify price increases by COLC guidelines, needed fertilizer was being attracted abroad by higher prices. After exemption of fertilizers, prices of ammonium nitrate, anhydrous ammonia, urea, and diammonium phosphate increased strongly while imported and domestic sodium nitrate prices remained steady, as did the price of ammonium sulfate.

Table 5.—Price quotations for major nitrogen compounds in 1973

(Per short ton)

Compound	Jan. 1	Dec. 31
Ammonium nitrate, domestic, fertilizer-grade, 33.5% nitrogen, bulk, delivered	\$47–\$49	\$47–\$78
Ammonium sulfate, standard-grade, commercial, bulk, f.o.b. works	--	15–25
Anhydrous ammonia, fertilizer, wholesale, tanks, delivered east of Rockies, except East Coast	55–65	60–110
Aqueous ammonia, 29.4% NH_3, anhydrous basis, tanks, freight equalized, east of Rockies	65–70	76–79
Delivered east coast	60–65	60–65
Sodium nitrate, domestic, agricultural, bulk, carlots, f.o.b. works	51.50	51.50
Bags, carlots, f.o.b. works	55.50	55.50
Sodium nitrate, imported, commercial, bulk, carlots, f.o.b. Atlantic and Gulf warehouses	51.50	51.50
100-pound bags, carlot, same basis	55.50	55.50
Urea:		
Industrial, 46% nitrogen, bulk, 50-ton carlots, delivered East	64–76	75–107
Agricultural, 46% nitrogen, bulk, same basis	62–63	73–107
Agricultural, 45% nitrogen, bulk, 50-ton carlots, delivered East	60–61	72–104
Diammonium phosphate, fertilizer grade, 18-46-0, bulk, carlots, f.o.b. Florida works	55–66	75–110
Bags, same basis	61–73.50	--

Source: Chemical Marketing Reporter.

FOREIGN TRADE

Exports of fixed nitrogen increased 15% in 1973, in terms of nitrogen content, while the value of exports rose 43%. A strong increase was registered in exports of ammonium phosphates which rose 23% in volume and 50% in value. Ammonium phosphates accounted for 59% of the value of fixed nitrogen exports. Urea exports decreased 15% in volume and increased 31% in value compared with 1972. Urea accounted for 10% of the total value of fixed nitrogen exports.

Imports of fixed nitrogen increased 2% in nitrogen content and 17% in value. Most of the increase was accounted for by larger imports of urea. Imports of sodium nitrate, all from Chile, declined 39% in 1973, continuing the decline registered the previous year.

Table 6.—U.S. exports and imports for consumption of major nitrogen compounds
(Thousand short tons and thousand dollars)

Compound	1972 Gross weight	1972 Nitrogen content e	1972 Value	1973 Gross weight	1973 Nitrogen content e	1973 Value
EXPORTS						
Industrial chemicals: Anhydrous ammonia and chemical grade aqua (ammonia content)	161	132	4,943	186	153	9,185
Fertilizer materials:						
Ammonium nitrate	22	7	1,183	41	14	3,670
Ammonium phosphates	1,816	327	126,046	2,235	402	189,065
Ammonium sulfate	520	107	14,006	528	109	15,378
Anhydrous ammonia and aqua (ammonia content)	551	452	17,001	717	588	32,045
Nitrogenous chemical materials n.e.c.	66	20	6,171	28	8	1,896
Sodium nitrate	1	(1)	74	1	(1)	59
Urea	500	228	25,298	427	194	33,054
Mixed chemical fertilizers	367	37	27,719	375	38	34,084
Total	4,004	1,310	222,441	4,538	1,506	318,436
IMPORTS						
Industrial chemicals: Ammonium nitrate	5	2	250	4	2	270
Fertilizer materials:						
Ammonium nitrate	378	127	16,576	338	112	15,367
Ammonium nitrate—limestone mixtures	(1)	(1)	13	10	2	393
Ammonium phosphates	501	90	31,070	393	51	27,290
Ammonium sulfate	264	54	7,310	299	62	10,610
Calcium cyanamide or lime nitrogen	3	(1)	312	4	1	462
Calcium nitrate	47	7	1,092	156	24	5,064
Nitrogen solutions	149	45	4,763	193	58	7,380
Anhydrous ammonia	386	317	17,001	312	256	15,468
Potassium nitrate or saltpeter, crude	21	3	1,673	48	6	3,101
Potassium nitrate, sodium nitrate mixtures	28	4	1,447	53	8	2,737
Sodium nitrate	111	18	3,865	69	11	2,833
Urea	556	253	25,565	674	337	38,865
Nitrogenous fertilizers n.s.p.f	34	7	1,710	91	18	4,973
Mixed chemical fertilizers	200	20	12,390	193	19	11,642
Total	2,683	947	125,037	2,837	967	146,455

e Estimate.
1 Less than ½ unit.

WORLD REVIEW

In recognition of an approaching shortage of nitrogenous fertilizers, plans were announced, and in certain cases construction started on numerous plants to produce the basic material, ammonia, for these products. The People's Republic of China, the U.S.S.R., and India were active in this regard, as well as other countries, particularly those with a ready supply of natural gas.

Angola.—A plan was announced to build a 230,000 short-ton-per-year ammonium sulfate plant as well as other plants for sulfuric acid and superphosphate. A fertilizer plant with a capacity of 250,000 short tons per year was also planned for the Caala region and was expected to be onstream in 1976.[14]

Bahrain.—A project to establish a nitrogenous fertilizer plant to produce 500,000 short tons per year, costing around $115 million, was under study by an Indian technical team.[15] The project would include a 1,100-short-ton-per-day ammonia plant and a 1,650-short-ton-per-day urea facility.

Bangladesh.—A credit of $80 million to construct a new 220,000-short-ton-per-day ammonia plant at Chittagong was authorized by the Indian Government.[16]

Bolivia.—Yacimientos Petrolíferos Fiscales Bolivianos (YPFB) has reached agreement with Yacimientos Petrolíferos Fiscales de Argentina to build a 1,100-short-ton-per-day ammonia plant and a 1,650-ton urea plant, probably at Santa Cruz. The plants will use domestic natural gas.[17]

Brazil.—Petrobrás Química S.A. awarded a contract to Kellogg International Corp. for the design and engineering of a 1,000-

[14] Chemical Age International. V. 107, No. 2837, Nov. 30, 1973, p. 18.
[15] Chemical Age International. V. 107, No. 2825, Sept. 7, 1973, p. 17.
[16] Nitrogen (London). No. 85, September—October 1973, p. 13.
[17] Nitrogen (London). No. 86, November—December 1973, p. 14.

ton-per-day ammonia plant and an 880-ton-per-day urea plant to be built at Camacari, Bahia. Cost of the project was estimated at $60 million and initial production was expected in 1975. The natural gas feedstock will be supplied by Petróleo Brasileiro S.A. from nearby gasfields.[18]

A 1,100-short-ton-per-day ammonia plant, with a 660-ton urea plant, was announced for Rio Grande do Sul State. A new company, Cia Rio Grandense de Nitrogenados S.A., with a 51% participation by the State government, was to operate the ammonia facility.[19]

Canada.—The calcium cyanamide plant of Cyanamid of Canada Ltd. was shutdown after having operated since 1907. Demand for the product as fertilizer had decreased. Other factors, including new technology, increased power costs, and environmental considerations, contributed to the closing.[20]

Allarco Chemicals Ltd. planned to build a 1,100-ton-per-day ammonia plant, with a 1,650-ton-per-day urea plant, at Medicine Hat, Alberta.[21]

Brockville Chemical Industries, Ltd. announced plans to build and operate a 500-ton-per-day plant costing $4 million to produce nitric acid at Maitland, Ontario. The plant was scheduled for startup during the second quarter of 1975. It will raise the productive capacity at Maitland to 1,000 tons per day.[22]

China, People's Republic of.—In the first sale of its kind by a U.S. firm, three 1,100-short-ton-per-day ammonia plants were ordered from the M. W. Kellogg Co. of Houston, Tex. The plants will use natural gas feedstock and the total cost was estimated at more than $70 million. Two ammonia plants sold earlier in the year to the People's Republic of China by Toyo Engineering of Japan also were to use Kellogg's ammonia process.[23]

A Kellogg affiliate, Kellogg Continental (Amsterdam) signed a contract to design, supply materials, and erect five 1,620-ton-per-day urea units. Total cost was estimated at about $55 million. This sale supplemented an earlier contract for three identical plants valued at $37 million. The first unit was slated for startup in late 1976.[24]

Egypt, Arab Republic of.—An agreement was reached between the Egyptian Industrialization Authority, the World Bank, and the Arab Development Fund for constructing a nitrogenous fertilizer plant in the Nile Delta area. The unit, located at Talcha, will have a capacity of 630,000 short tons per year. It is expected to supply the entire nitrogenous fertilizer requirements of lower Egypt.[25]

Hungary.—A 1,100-ton-per-day ammonia plant, being constructed at Pét, was scheduled for commissioning in 1975.[26]

India.—The capacity of the ammonia plant being constructed by Mangalore Chemicals and Fertilizers is to be increased from the originally planned 240,000 short tons per year to a total of 565,000 tons per year. Including additional investment in mixed fertilizers, the total investment was expected to be $150 million in addition to the original $75 million.

The Indian government was planning a 990-short-ton-per-day ammonia plant based on coal. This would be linked to a 1,390-short-ton-per-day urea plant. The technology was expected to be similar to that installed by the contractor, Imperial Chemical Industries, Ltd., at a coal-based urea plant in the Republic of South Africa. In addition, three public sector coal-based urea plants were being constructed in India; at Talcher (Orissa), Korba (Madhya Pradesh), and Ramgundam (Andhra Pradesh).[27]

A new 1,000 short-ton-per-day ammonia plant based on fuel oil was to be built at Nongal, Punjab; a contract for design and construction was signed with Friedrich Uhde GmbH, of West Germany.[28]

Iran.—The Shahpur Chemical Co. awarded Krebs et Cie. a contract to expand their urea plant from 500 to 700 tons per day.[29]

Iraq.—A large fertilizer production complex based on natural gas will be built

[18] Chemistry and Industry. No. 10, May 19, 1973, p. 473.
[19] Work cited in footnote 16.
[20] Chemical Age International. V. 107, No. 2823, Aug. 24, 1973, p. 15.
[21] Nitrogen (London). No. 84, July—August 1973, p. 10.
[22] Chemical Marketing Reporter. V. 204, No. 24, Dec. 10, 1973, p. 27.
[23] Chemical & Engineering News. V. 51, No. 29, July 16, 1973, p. 11.
[24] Chemical Week. V. 113, No. 11, Sept. 12, 1973, p. 17.
[25] Chemical Age International. V. 107, No. 2836, Nov. 23, 1973, p. 20.
[26] Page 16 of work cited in footnote 6.
[27] Chemical Age International. V. 107, No. 2834, Nov. 9, 1973, p. 15.
[28] Chemical Age International. V. 107, No. 2826, Sept. 14, 1973, p. 6.
[29] Chemical Age International. V. 107, No. 2827, Sept. 21, 1973, p. 18.

at Basrah by the Ministry of Industry under a contract awarded to Mitsubishi Heavy Industries. A urea plant, with a capacity of 1,430 short tons per day, and an ammonia plant, with a capacity of 880 tons per day, will be included in the complex, the total cost of which was estimated to be over $100 million.[30]

Ireland.—The State-sponsored fertilizer company, Nitrigin Eireann Teoranta (NET), announced plans to build a $50 million plant for processing ammonia from natural gas or naphtha in the Cork Harbor area. The capacity of the plant will be 1,100 short tons of ammonia per day. It will employ 350 people and production is expected to start in 1977. If natural gas becomes available from the Irish offshore area, the gas will be used in the plant, although the plant is designed initially to use naphtha as a raw material. Of the total production, about one-third will be exported, one-third will be used at NET's fertilizer plant at Arklow, County Wicklow, and the balance will be processed on the site to manufacture about 500 tons per day of urea.[31]

Italy.—An ammonium nitrate plant with a capacity of 1,100 short tons per day was under construction at the Azienda Nazionale Idrogenazione Combustibili S.p.A. petrochemical complex at Ravenna. The plant is scheduled to begin production at the end of 1974.[32]

Korea, Republic of (South).—As part of its third 5-year plan (1972–76), Korea will build a second petrochemical complex and a $181 million fertilizer operation at Yosu on the southern coast. The complex will include an ammonia plant with a capacity of 550,000 short tons per year, a urea plant with a capacity of 250,000 tons per year, and capacity for 17,000 tons per year of ammonium nitrate. All the fertilizer units will be owned by Korea Integrated Chemicals, a joint venture of Honam Fertilizer and the Korean Government.[33]

The sixth large fertilizer plant at Chung Ju came into operation. The capacity of the new plant is 330,000 short tons per year of ammonia and 255,000 tons per year of urea. The plant which used naphtha feedstock was built with the help of a foreign consortium consisting of the U.S. Agency for International Development, Barclay's Corp., and the Mitsubishi Industrial Group.[34]

Libya.—A 1,100-short-ton-per-day ammonia plant was to be built at Marsa el Brega for Libya's National Oil Corporation. A contract for supply of the plant and offsites was placed with Friedrich Uhde GmbH of Dortmund, West Germany. The plant is due onstream in 1976.[35]

Pakistan.—A urea ammonium phosphate plant will be designed and supplied by Sim Chem, a division of Simon-Carves, for the Pakistan Fertilizer Co., Ltd., at Karachi. The design capacity is 220,000 tons per year and the plant will be financed through a World Bank loan.[36]

The Pakistan Industrial Development Corporation issued a tender for the design and engineering of a fertilizer complex to be built at Multan. It was to include a 1,000-short-ton-per-day ammonia plant.[37]

The National Fertilizer Corp., owned by the Government of Pakistan, decided to build a second major nitrogenous fertilizer plant beside the present plant at Multan. The project will include a 1,000-short-ton-per-day ammonia plant, two nitric acid plants of 660-short-ton-per-day capacity each, one 1,120-ton-per-day prilled nitrophosphate plant and one 1,600-ton-per-day prilled ammonium nitrate plant. The engineering and procurement contract for the ammonia plant was awarded to Kellogg International Corp. Total cost of the entire expansion was expected to be $100 million, approximately $75 million of which will be foreign exchange cost provided by the Asian Development Bank, the World Bank, and the Abu Dhabi National Oil Co. The latter will obtain 30% of the share capital.[38]

Romania.—Expansion of the Azotul Four ammonia unit at Piatra Neamt was completed. The additional capacity will increase nitrogen fertilizer output by 140,000 tons per year.[39]

Spain.—A 330,000-short-ton-per-year am-

[30] Chemical Age International. V. 107, No. 2831, Oct. 19, 1973, p. 24.
[31] U.S. Embassy, Dublin, Ireland. State Department Airgram A–161, Nov. 28, 1973. 1 p.
[32] Chemical Age International. V. 107, No. 2819, July 27, 1973, p. 13.
[33] Chemical Week. V. 112, No. 26, June 27, 1973, p. 39.
[34] Page 19 of work cited in footnote 25.
[35] Chemical Marketing Reporter. V. 204, No. 22, Nov. 26, 1973, p. 34.
[36] Page 5 of work cited in footnote 15.
[37] Page 19 of work cited in footnote 4.
[38] U.S. Consulate, Karachi, Pakistan. State Department Airgram A–53, May 17, 1974. P. 3.
[39] Chemical Age International. V. 107, No. 2835, Nov. 16, 1973, p. 21.

monia plant and a 180,000-short-ton-per-year urea plant were under construction by Unión ExplosivosRio Tinto S.A. at Seville. The plants were expected to be completed in 1975.[40]

A $4 million contract for the engineering, procurement and construction of a 330-short-ton-per-day urea plant at Malaga was awarded by Amoniaco Español S.A. to McKee-CTIP Ingenieros of Madrid. When the plant is completed in September 1974, it will produce urea prills for direct use as fertilizer.

Sudan.—The Sudanese Government awarded a $60 million contract to a subsidiary of Compagnie Française des Petroles covering the installation of a plant to produce 440 short tons per day of ammonia and 740 tons per day of urea. Naphtha feedstock was expected to come from a nearby refinery owned by the British Petroleum Co., Ltd. and the Royal Dutch/Shell group.

Taiwan.—A 330,000-short-ton-per-year ammonia plant and a 110,000-ton urea plant were expected to be built by Taiwan Fertilizer Co. at Miaoli.[41]

Trinidad and Tobago.—A project for two-phase construction of a 1,200-ton-per-day ammonia plant, followed by another ammonia unit of the same size and a 3,000-ton-per-day methanol plant was announced. The project will be a fifty-fifty joint venture between W. R. Grace & Co. and the National Petroleum Co., which is controlled by the Trinidad-Tobago Government. The first phase of the project will cost an estimated $50 million and should be in operation in 1976. The second phase will cost $80 million. Natural gas for the plant will be supplied from offshore gas wells. The product will be marketed in the United States, Europe, and South America.[42]

Turkey.—An air separation plant, with a production capacity of 600,000 cubic feet per day of gases, including nitrogen, argon, helium, and acetylene, was opened by Anatolian Industrial Gas at Izmit, near Istanbul.[43]

An ammonia urea complex was also to be built in the Izmit area for Igsas Istanbul Gubre Sanayii A.S. Some 1,100 tons per day of ammonia and 1,100 tons per day of urea will be produced starting late in 1975. Design, construction, and procurement will be carried out by the firm of Friedrich Uhde GmbH. The project is financed in part by a $24 million loan from the International Bank for Reconstruction and Development.[44] Total cost was estimated at $57 million.

U.S.S.R.—A 20-year barter arrangement for the joint production and sale of fertilizers was signed by Occidental Petroleum Corp. of the United States and the Soviet Government. Occidental was to contract for building several ammonia and urea plants in the U.S.S.R. and to supply 1 million tons per year of superphosphoric acid. In return the Soviet Government would supply up to 1 million tons of potash, 1 to 1.5 million tons of urea, and 3 million tons per year of ammonia to Occidental, which would market it in the United States. Total value of the deal was estimated at $8 billion. The ammonia complex would be built at Kuibyshev, southeast of Moscow.[45]

A contract for the construction of seven chemical plants in the Soviet Union was awarded to the Italian firm, Montecatini Edison S.p.A. Included will be two ammonia plants, each of 550,000-short-ton-per-year capacity, and one urea plant, also of 550,000-short-ton-per-year capacity.[46]

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[40] Chemical Age International. V. 107, No. 2820, Aug. 3, 1973, p. 12.
[41] Page 14 of work cited in footnote 16.
[42] Chemical Week. V. 112, No. 19, May 9, 1973, p. 13.
[43] Chemical Age International. V. 107, No. 2833, Nov. 2, 1973, p. 10.
[44] Chemical Age International. V. 107, No. 2822, Aug. 17, 1973, p. 15.
[45] Chemical Engineering. V. 80, No. 10, Apr. 30, 1973, p. 31.
[46] Chemical Week. V. 113, No. 4, July 25, 1973, p. 24.

Table 7.—Fertilizer nitrogen compounds: World production and consumption for years ended June 30, by country

(Thousand short tons of contained nitrogen)

Country	Production			Consumption		
	1970–71	1971–72	1972–73	1970–71	1971–72	1972–73
North America:						
Canada	800	887	882	322	386	485
Costa Rica	13	19	18	[1] 41	[1] 30	[1] 29
Cuba	5	[e] 11	12	[1] 175	[e 1] 110	[1] 121
Dominican Republic	--	--	--	17	29	29
El Salvador [e]	9	9	2	50	69	72
Guatemala	--	[e] 3	--	32	15	26
Mexico	364	361	393	483	572	572
Netherlands Antilles [e]	48	13	20	--	--	--
Trinidad and Tobago [e 2]	110	104	126	6	7	8
United States (includes Puerto Rico)	8,996	8,919	9,339	8,134	8,016	8,339
South America:						
Argentina	38	44	42	45	50	54
Brazil [1]	24	75	78	307	307	435
Chile [1]	[e] 137	[e] 139	[e] 117	49	53	58
Colombia [1]	[e] 64	76	79	[e] 71	97	154
Ecuador [e]	2	--	2	20	9	14
Peru [3]	[e] 22	28	30	[e] 73	90	94
Venezuela	11	6	6	[1] 28	[1] 37	[1] 39
Europe:						
Albania [e 1]	31	33	40	30	32	36
Austria	241	255	253	139	154	150
Belgium	654	676	712	184	184	184
Bulgaria [1]	663	619	577	418	355	390
Czechoslovakia	[1] 388	[e 1] 404	[1] 451	[e] 462	[e] 462	[e] 516
Denmark	81	83	85	319	340	363
Finland	213	221	268	187	201	201
France	1,489	1,562	1,622	1,602	1,681	1,830
Germany, East [1]	436	428	472	564	636	717
Germany, West	1,659	1,456	1,621	1,246	1,247	1,311
Greece	195	214	243	221	227	231
Hungary [1]	386	416	412	431	434	465
Iceland [1]	8	8	9	13	15	14
Ireland	[e] 87	[e] 97	[e] 93	96	108	144
Italy	1,054	1,140	1,152	655	689	763
Luxembourg	[e] 2	[e] 2	[e] 2	12	13	14
Netherlands	1,055	1,144	1,328	447	412	413
Norway	408	423	436	86	90	87
Poland	[1] 1,135	[1] 1,191	[1] 1,265	907	1,000	1,079
Portugal	105	[e] 161	165	84	[e] 136	144
Romania [1]	713	911	963	404	475	464
Spain	653	742	758	678	684	735
Sweden [4]	180	195	187	249	258	257
Switzerland	28	27	29	40	41	43
U.S.S.R. [1]	5,978	6,674	[e] 7,500	5,076	5,712	6,199
United Kingdom [4]	824	852	899	[5] 883	[5] 1,025	[5] 1,044
Yugoslavia [1]	294	280	294	324	367	375
Africa:						
Algeria [e]	25	43	55	32	87	94
Egypt, Arab Republic of	[1] 130	[e 1] 132	[1] 167	[6] 365	[6] 358	[6] 386
Ivory Coast [e]	2	2	8	[1] 9	[1] 6	[1] 10
Kenya [e]	--	--	--	24	20	26
Morocco [1]	[e] 14	22	13	[e] 41	53	72
Mozambique	1	2	10	5	7	8
Rhodesia, Southern [e]	40	67	64	54	78	66
Senegal	5	8	10	4	6	8
South Africa, Republic of [e 1]	220	246	273	199	230	279
Sudan [e]	--	--	--	49	53	59
Tanzania	--	--	1	9	12	9
Tunisia [e]	[1] 1	[1] 1	[1] --	14	20	17
Zambia	7	10	8	22	36	20
Asia:						
Bangladesh [e]	28	28	101	44	46	49
Burma	17	17	55	16	24	51
China, People's Republic of [e 1 7]	1,356	1,833	2,265	3,264	3,268	3,637
India	924	1,043	1,159	1,639	1,941	1,960
Indonesia	50	53	66	[e] 222	216	383
Iran	[e] 34	[e] 95	119	72	118	119
Iraq	[e] 7	12	22	[e] 13	15	17
Israel	22	22	26	35	36	37
Japan	2,320	2,343	2,705	[8] 962	[8] 743	[8] 808
Korea, North [e 1]	226	243	254	226	239	249
Korea, Republic of [1]	425	[e] 496	461	392	[e] 383	411
Kuwait	94	203	297	--	--	--
Lebanon [e]	15	8	3	[1] 21	32	36

See footnotes at end of table.

Table 7.—Fertilizer nitrogen compounds: World production and consumption for years ended June 30, by country—Continued

(Thousand short tons of contained nitrogen)

Country	Production			Consumption		
	1970–71	1971–72	1972–73	1970–71	1971–72	1972–73
Asia—Continued						
Malaysia, West [e]	29	47	44	65	77	83
Pakistan [9]	141	237	302	277	400	426
Philippines	53	[e] 65	61	131	[e] 134	126
Saudi Arabia [e]	25	38	76	1	2	2
Sri Lanka	--	--	--	[e] 64	49	63
Syrian Arab Republic	--	4	17	29	35	37
Taiwan [10]	216	209	209	170	194	176
Thailand	[e 1] 11	[1] 11	[1] 8	[e] 47	[e] 68	[e] 68
Turkey [1]	[e] 90	[e] 81	160	268	316	413
Vietnam, North [e 1]	--	--	--	42	34	12
Vietnam, South [e 1]	--	--	--	77	108	165
Oceania: Australia [e]	160	187	201	159	138	182
Other:						
North and Central America [e 11]	--	--	--	76	82	87
South America [e 12]	--	--	--	29	36	37
Europe [13]	--	--	--	2	2	2
Africa [e 14]	--	--	--	101	121	123
Asia [e 15]	--	--	--	44	42	55
Oceania [16]	--	--	--	14	29	42
World total	36,291	38,716	42,202	34,939	36,749	39,608

[e] Estimate.
[1] Calendar year referring to the first part of the split year.
[2] Excludes nitrogen content of anhydrous ammonia produced for export in that form for subsequent processing elsewhere.
[3] Includes guano.
[4] Fertilizer year: June–May.
[5] Deliveries by manufacturers or importers to first buyers.
[6] Fertilizer year: November–October.
[7] United States Bureau of Mines estimate based on United Nations' estimate for the People's Republic of China and Taiwan (reported as a single figure) less the British Sulphur Corp. Ltd. reported figure for Taiwan alone.
[8] Includes data for Okinawa prefecture (formerly known as Ryukyu Islands).
[9] Excluding data for Bangladesh shown separately above.
[10] Source: British Sulphur Corp. Ltd. Statistical Supplement No. 8, November–December 1973, London 1973, pp. 14–15.
[11] Includes Barbados, British Honduras, Guadeloupe, Haiti, Honduras, Jamaica, Martinique, Nicaragua, Panama, St. Kitts, Nevis and Anguilla, St. Lucia, and St. Vincent.
[12] Includes Bolivia, Guyana, Paraguay, Surinam, and Uruguay.
[13] Includes Channel Islands (Jersey only) and Isle of Man.
[14] Includes Angola, Botswana, Cameroon, Central African Republic, Chad, Congo (Brazzaville), Dahomey, Equatorial Guinea, Ethiopia, Ghana, Guinea, Liberia, Libya, Malagasy Republic, Malawi, Mali, Mauritius, Nigeria, Reunion, Sierra Leone, Somalia, Swaziland, Togo, Uganda, Upper Volta, and Zaire.
[15] Includes Afghanistan, Burundi, Cyprus, Jordan, Khmer Republic, Laos, Mongolia, Nepal, and Singapore.
[16] Includes Fiji Islands and New Zealand.

Source: Statistical Office of the United Nations, Statistical Yearbook, 1973. New York, 1974, pp. 270–271, 513–515, unless otherwise specified.

TECHNOLOGY

The sulfur-coated urea (SCU) product developed by the Tennessee Valley Authority was intensively studied during the year. Application of molten sulfur was found to be superior to the previous dry application to coat the urea. Improvements included better coating efficiency and uniformity, less dust and mist formation, simplified coating drum design, and decreased requirements for preheating the urea. SCU was originally produced with a sealing coat of wax over the sulfur. During the year progress was made in eliminating the wax coating when desired. It was found that SCU was more effective in rice cultivation where the fields are alternately flooded and drained as in developing nations where water supplies are inadequate. SCU maintains its slow release characteristics. Furthermore, it has the advantage of supplying nitrogen in the ammonium form which suffers less from leaching and volatilization than the nitrate form.[47]

[47] National Fertilizer Development Center, Tennessee Valley Authority. 1973 Annual Report, pp. 3 and 5.

The detection of atmospheric nitrogen compounds, including low concentrations of nitrogen oxides, is of considerable interest in determining air quality. A method of detecting these compounds by flame chemiluminescence was described.[48] A hydrogen-rich oxyhydrogen flame was used as the medium for excitation of characteristic nitrogen bands. The emission observed in the reaction between atomic hydrogen and NO was viewed photometrically. The detection limit was 0.150 parts per million for nitrogen oxides. Sulfur dioxide was also detected in concentrations of 0.004 parts per million.

A method was proposed for analyzing nitric oxide-nitrogen dioxide mixtures by reacting them with iron in sulfolane. The sensitivity of the method is only moderate but it appears to have potentialities for the analysis of grab samples collected at NO_x emission sources.[49] It was reported that nitric oxide can be measured in an air sample with a new laser magnetic resonance device developed by the National Bureau of Standards. The Zeeman effect, a split of molecular energy levels under a magnetic field, is particularly pronounced for nitric oxide at a wave length of 5.307 micrometers. No other contaminant exhibits this effect at this frequency.[50]

NO_x abatement from flue gases in Japan was described.[51] Japanese environmental emission and control standards and measurement methods were covered. Thirteen processes were described for NO_x abatement from waste gases. Two promising developments were a new type of burner for combustion modification and catalytic reduction for NO_x removal from flue gases.

The Arbiter process was developed by The Anaconda Company and a plant to produce 100 tons per day of copper product was under construction at the Anaconda, Montana smelter. The process, which is pollution-free, was essentially an ammonia leach using oxygen but requiring no pressure or elevated temperature. It was claimed that the process can treat lower grade and highly pyritic concentrates such as those from old tailings.[52] The plant was estimated to cost $22 million and will produce 36,000 tons per year of copper. This investment cost was estimated to be about 60% of the investment for a conventional smelter of equivalent capacity.

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[48] Krost, K. J., J. A. Hodgeson, and R. K. Stevens. Flame Chemiluminescence Detection of Nitrogen Compounds. Anal. Chemistry, v. 45, No. 11, September 1973, pp. 1800–1804.

[49] Coetzee, J. F., D. R. Balya. and P. K. Chattopadhyay. Differential Kenetic Analysis of Nitric Oxide-Nitrogen Dioxide Mixtures by Reaction With Iron (II) in Sulfolane as Solvent. Anal. Chemistry, v. 45, No. 13, November 1973, pp. 2266–2268.

[50] Chemical and Engineering News. V. 51, No. 31, July 30, 1973, p. 11.

[51] Tohata, H., and J. Ando. Nitrogen Oxide Abatement Technology in Japan, 1973. National Technical Information Service, U.S. Department of Commerce, Springfield, Va. 22151, 37 pp.

[52] Chemical Engineering. V. 80, No. 9, Apr. 16, 1973, p. WW.

Peat

By Eugene T. Sheridan [1] and Donald P. Mickelsen [2]

Peat production in the United States increased 10% in 1973, principally because of greater output at several of the larger operations. Although the number of active plants decreased by 5, production increased in 13 States. The largest production gains were recorded in Michigan, Indiana, Pennsylvania, Washington, and South Carolina.

Commercial sales of peat were 2% higher than in 1972, but the total value of peat sold, f.o.b. plant, rose 6% as the average value of all peat sold in 1973 increased $0.44 per ton.

Imports increased 4%, and the quantity of peat imported in 1973 was about one-half the quantity produced domestically. Ninety-five percent of the peat imported was shipped from Canada.

World production was estimated at 106.5 million short tons. The U.S.S.R. was the largest producer with an output estimated at 96 million tons, 90% of the world total.

[1] Mineral specialist, Division of Fossil Fuels —Mineral Supply.

[2] Statistical assistant, Division of Fossil Fuels —Mineral Supply.

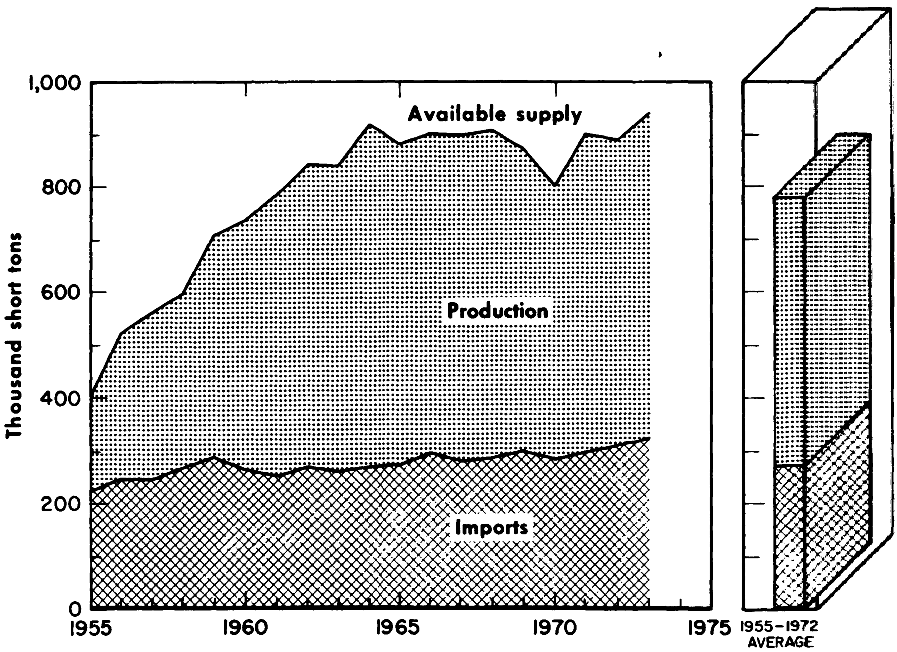

Figure 1.—Production, imports, and available supply of peat in the United States.

DOMESTIC PRODUCTION

The 58,000-ton increase in production resulted mainly from a larger output of humus. Of the reported total production, about one-half was reed-sedge peat, whereas the remainder was about equally divided between moss peat and humus.

Peat was produced in 22 States in 1973. Michigan remained the largest producer, with about one-third of the Nation's output. Illinois, Indiana, New Jersey, Florida, and Pennsylvania followed in output in the order named. These States, with Michigan, had three-fourths of the total production.

Active operations decreased from 103 to 98, but average output per plant increased 16% to 6,475 tons. Three-fourths of the operations, however, had outputs smaller than the average. Only 28 plants had production in excess of 5,000 tons, and only 6 plants produced more than 25,000 tons.

Roughly one-third of the peat was sold as produced with no processing other than air drying. Most of the remainder was shredded, and a small quantity was subjected to thermal drying.

Table 1.—Salient peat statistics

	1970	1971	1972	1973
United States:				
Number of operations	122	120	103	98
Production ____short tons__	516,825	605,382	576,712	634,503
Value ____thousands__	525,603	599,548	606,679	620,583
Commercial sales ____do____	$5,986	$7,011	$7,112	$7,547
Average per ton	$11.39	$11.69	$11.72	$12.16
Imports ____short tons__	283,211	296,283	r 310,521	323,501
Available for consumption [1] ____do____	808,814	895,831	r 917,200	944,084
World: Production ____thousand short tons__	92,026	r 100,103	116,029	p 106,481

p Preliminary. r Revised.
[1] Commercial sales plus imports.

Table 2.—Peat produced in the United States in 1973, by kind
(Short tons)

Kind	Unprepared	Processed			Total
		Shredded	Kiln-dried only	Shredded and kiln-dried	
Moss	64,365	82,465	--	2,625	149,455
Reed-sedge	107,557	229,426	--	--	336,983
Humus	25,544	120,343	2,178	--	148,065
Total	197,466	432,234	2,178	2,625	634,503

Table 3.—Production and commercial sales of peat in the United States in 1973, by State

State	Active plants	Production (short tons)	Commercial sales: Quantity (short tons)	Commercial sales: Value: Total (thousands)	Commercial sales: Value: Average per ton
California	3	21,799	20,803	$373	$17.91
Florida	8	28,413	28,040	163	5.81
Colorado	8	43,777	44,062	384	8.71
Georgia	1	385	385	4	9.09
Illinois	6	71,552	71,551	1,037	14.49
Indiana	9	49,506	50,741	475	9.36
Iowa	2	W	W	W	W
Maine	3	5,817	4,686	177	37.67
Maryland	1	2,349	2,349	29	12.24
Massachusetts	1	2,400	2,400	78	32.50
Michigan	17	236,340	232,330	2,172	9.35
Minnesota	3	W	W	W	W
Montana	1	720	720	W	W
New Jersey	4	46,472	44,088	514	11.65
New Mexico	1	2,750	2,750	50	18.13
New York	4	11,221	11,221	166	14.78
Ohio	8	3,899	3,899	64	16.49
Pennsylvania	9	30,293	27,802	411	14.77
South Carolina	1	17,200	14,000	W	W
Vermont	1	95	95	2	23.36
Washington	5	21,467	21,467	110	5.13
Wisconsin	2	2,261	1,959	208	106.15
Total	98	634,503	620,583	7,547	12.16

W Withheld to avoid disclosing individual company confidential data; included in total.

Table 4.—Relative size of peat operations in the United States

Size	1972 Active plants: Number	1972 Active plants: Percent of total	1972 Production: Short tons	1972 Production: Percent of total	1973 Active plants: Number	1973 Active plants: Percent of total	1973 Production: Short tons	1973 Production: Percent of total
Under 500 tons	26	25.2	6,142	1.0	19	19.4	3,620	0.6
500 to 999 tons	11	10.7	7,678	1.3	11	11.2	7,798	1.2
1,000 to 4,999 tons	38	36.9	86,279	15.0	40	40.8	98,076	15.5
5,000 to 14,999 tons	18	17.5	170,153	29.5	15	15.3	123,368	19.4
15,000 to 24,999 tons	6	5.8	111,240	19.3	7	7.2	117,439	18.5
Over 25,000 tons	4	3.9	195,220	33.9	6	6.1	284,202	44.8
Total	103	100.0	576,712	100.0	98	100.0	634,503	100.0

CONSUMPTION AND USES

Commercial sales and imports both increased in 1973, and the amount of peat available for consumption was about 3% greater than in 1972.

Peat was used for a variety of purposes, but 87% of total commercial sales reported by producers was for general soil improvement. Among the principal markets for this peat were nurseries and greenhouses, which used peat as a mulch and a medium for growing plants and shrubs; landscape gardeners and contractors, who used peat for building lawns, golf course greens, and for transplanting trees and shrubs; and garden, hardware, and variety stores, which sold peat to homeowners for mulching and for improving lawn and garden soils. Most of the remaining peat was sold for use in potting soils and for packing flowers and shrubs, but small quantities were used in mushroom beds and mixed fertilizers, and for earthworm culture and seed inoculant.

Fifty-eight percent of the tonnage of peat sold commercially by producers was packaged. Packaged peat, however, accounted for more than two-thirds of the total value of sales. Of the total peat sold in packages, about two-thirds was reed-sedge peat, about one-fifth was moss peat, and the remainder was humus.

States leading in sales of packaged peat were Michigan, Illinois, and Indiana, which, together, reported 80% of the total sales of packaged peat. Michigan was the largest producer of packaged peat with 56% of the total sales.

Table 5.—Commercial sales of peat in the United States in 1973, by kind and use

Use	Moss		Humus		Reed-sedge	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Bulk:						
Soil improvement	47,475	$435	74,400	$756	71,584	$593
Other uses	33,631	244	10,969	109	22,769	169
Total [1]	81,106	680	85,369	866	94,353	761
Packaged:						
Soil improvement	60,634	1,222	239,352	2,746	46,867	746
Other uses	3,683	124	6,709	121	2,510	282
Total	64,317	1,346	246,061	2,867	49,377	1,028
Total:						
Soil improvement	108,109	1,657	313,752	3,502	118,451	1,338
Other uses	37,314	368	17,678	231	25,279	451
Grand total	145,423	2,025	331,430	3,733	143,730	1,789

[1] Data may not add to totals shown because of independent rounding.

Table 6.—Commercial sales of peat in the United States in 1973, by use

Use	In bulk		In packages		Total [1]	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Soil improvement	193,459	$1,784	346,853	$4,713	540,312	$6,497
Seed inoculant	25	(2)	2,675	257	2,700	257
Packing flowers, shrubs, etc	27,455	222	928	23	28,383	244
Potting soils	20,300	169	9,262	248	29,562	417
Mushroom beds	1,586	21	--	--	1,586	21
Earthworm culture	5,334	55	37	(2)	5,371	55
Mixed fertilizers	12,599	55	--	--	12,599	55
Adsorption medium	70	1	--	--	70	1
Total [1]	260,828	2,307	359,755	5,241	620,583	7,547

[1] Data may not add to totals shown because of independent rounding.
[2] Less than ½ unit.

PRICES AND SPECIFICATIONS

Prices of peat at individual operations varied greatly in 1973, with the price depending mainly upon the kind of peat sold, the amount of processing, and whether the material was sold packaged or in bulk.

The overall average value per ton, f.o.b. plant, for all peat sold in 1973 was $12.16. This was an increase of $0.44 per ton over the average value of 1972. The bulk of the increase was attributed mainly to higher average receipts for peat sold by producers in Minnesota, Illinois, and Iowa.

The average price of bulk peat increased $0.65 per ton to $8.84. Packaged prices, however, decreased an average of $0.11 per ton to $14.57. The average price for bulk peat was influenced mainly by higher overall prices for bulk sales by producers in Florida, New Jersey, Indiana, and Pennsylvania. The decline in the unit value of packaged peat was attributed to generally smaller receipts for each ton of packaged peat sold by Michigan producers.

In a few instances, producers did not report the value of the peat they sold, and a value was assigned to their sales that was based upon the average value of peat sold within the State.

Imported peat had a total value of $18.8 million. The total value of imported peat was 9% greater than in 1972, partially because there was 13,000 tons more peat imported but, also, because the average value per ton increased from $55.30 to $58.00.

Although the average value of imported peat was over four times that of domestically produced packaged peat, their values are not comparable because they are assigned at different marketing levels. Also, imported peat has different physical properties than most of the domestic peat, and it usually is sold on a volume basis rather than by weight. Each 100 pounds of a typical air-dried imported peat will measure approximately 12 bushels, whereas the same quantity of a typical domestic peat will measure 3 to 4 bushels. Only a few domestic operations produced peat with properties similar to those of the imported kind.

Peat is broadly classified in the United States as moss peat, reed-sedge peat, and humus, according to the materials from which it has been formed and its degree of decomposition. Moss peat is a type that has been formed principally from sphagnum, and/or other mosses; reed-sedge peat has originated mainly from reeds, sedges, and other swamp plants; and humus is peat too decomposed for identification of its biological origin.

FOREIGN TRADE

The quantity of peat imported into the United States in 1973 totaled 324,000 short tons. This was 4% more peat than was imported in 1972 and the largest quantity imported in any year to date.

Canada provided the bulk of the imports, supplying 95% of the total peat imported. Virtually all of the remaining foreign peat was supplied by Europe.

European shipments increased 44% principally because of substantially larger shipments from West Germany. West Germany supplied 96% of the peat imported from Europe.

Imported peat was classified according to use as poultry- and stable-grade peat and fertilizer-grade peat. Of the total imported, 98% was fertilizer-grade peat. Except for a duty of $0.50 per long ton levied on poultry- and stable-grade peat from communist countries, there is no tariff on peat.

Foreign peat entered the United States through 29 customs districts in 1973, but 84% of the total was shipped through the Buffalo and Ogdensburg, N.Y.; Detroit, Mich.; Pembina, N. Dak.; St. Albans, Vt.; and Seattle, Wash., customs districts. The largest quantity, 90,000 tons, was shipped through the Ogdensburg district.

Table 7.—U.S. imports for consumption of peat moss, by grade and country

Country	Poultry and stable grade		Fertilizer grade		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
1972						
Canada	2,057	$162	296,743	$16,335	298,800	$16,497
France	--	--	14	1	14	1
Germany, West	857	46	7,337	450	8,194	496
Ireland	--	--	14	1	14	1
Norway	22	2	--	--	22	2
Poland	187	6	3,075	163	3,262	169
Sweden	r 33	3	--	--	r 33	3
Taiwan	22	1	--	--	22	1
U.S.S.R.	110	2	--	--	110	2
United Kingdom	--	--	50	1	50	1
Total	r 3,288	222	307,233	16,951	r 310,521	17,173
1973						
Canada	4,718	271	301,887	17,475	306,605	17,746
Germany, West	1,104	66	15,012	870	16,116	936
Guyana	--	--	18	1	18	1
Hong Kong	7	20	--	--	7	20
Ireland	13	10	172	18	185	28
Japan	--	--	50	2	50	2
Netherlands	--	--	7	1	7	1
Norway	3	4	--	--	3	4
Poland	--	--	332	17	332	17
Thailand	--	--	19	1	19	1
U.S.S.R.	17	1	114	4	131	5
United Kingdom	--	--	21	1	21	1
Venezuela	--	--	7	(1)	7	(1)
Total	5,862	372	317,639	18,390	323,501	18,762

r Revised.
1 Less than ½ unit.

Table 8.—U.S. imports for consumption of peat moss in 1973, by grade and customs district

Customs district	Poultry and stable grade		Fertilizer grade		Total	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Anchorage, Alaska	--	--	69	$4	69	$4
Baltimore, Md	16	$1	1,160	68	1,176	69
Boston, Mass	7	1	452	30	459	31
Buffalo, N.Y	243	14	24,811	1,382	25,054	1,396
Charleston, N.C	231	10	91	4	322	14
Chicago, Ill	13	10	--	--	13	10
Cleveland, Ohio	--	--	18	4	18	4
Detroit, Mich	109	5	47,934	2,934	48,043	2,939
Duluth, Minn	--	--	5,039	459	5,039	459
Great Falls, Mont	--	--	13,291	776	13,291	776
Houston, Tex	--	--	1,452	74	1,452	74
Los Angeles, Calif	66	3	1,283	127	1,349	130
Miami, Fla	--	--	313	14	313	14
Milwaukee, Wis	--	--	20	1	20	1
Mobile, Ala	55	3	617	40	672	43
New Orleans, La	--	--	2,862	127	2,862	127
New York, N.Y	86	6	1,399	86	1,485	92
Norfolk, Va	--	--	695	32	695	32
Ogdensburg, N.Y	--	--	89,525	4,796	89,525	4,796
Pembina, N. Dak	1,152	79	22,377	1,206	23,529	1,285
Philadelphia, Pa	126	18	949	61	1,075	79
Portland, Maine	3,087	167	14,176	814	17,263	981
Portland, Oreg	148	10	103	7	251	17
St. Albans, Vt	84	3	36,226	1,924	36,310	1,927
San Francisco, Calif	49	3	318	20	367	23
San Juan, P.R	--	--	1,000	69	1,000	69
Savannah, Ga	--	--	127	7	127	7
Seattle, Wash	23	15	48,428	3,177	48,451	3,192
Tampa, Fla	367	24	2,904	147	3,271	171
Total	5,862	372	317,639	18,390	323,501	18,762

Table 9.—Peat moss imported for consumption from Canada and West Germany in 1973, by grade and customs district

Customs district	Canada				West Germany			
	Poultry and stable grade		Fertilizer grade		Poultry and stable grade		Fertilizer grade	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Anchorage, Alaska	--	--	69	$4	--	--	--	--
Baltimore, Md	--	--	--	--	16	$1	1,153	$67
Boston, Mass	7	$1	--	--	--	--	290	13
Buffalo, N.Y	243	14	24,811	1,382	--	--	--	--
Charleston, N.C	--	--	--	--	231	10	91	4
Cleveland, Ohio	--	--	18	4	--	--	--	--
Detroit, Mich	109	5	47,934	2,934	--	--	--	--
Duluth, Minn	--	--	5,039	459	--	--	--	--
Great Falls, Mont	--	--	13,291	776	--	--	--	--
Houston, Tex	--	--	--	--	--	--	1,353	70
Los Angeles, Calif	--	--	--	--	66	3	1,283	127
Miami, Fla	--	--	--	--	--	--	313	14
Milwaukee, Wis	--	--	20	1	--	--	--	--
Mobile, Ala	--	--	--	--	55	3	617	40
New Orleans, La	--	--	38	2	--	--	2,674	119
New York, N.Y	17	1	--	--	52	4	1,321	82
Norfolk, Va	--	--	--	--	--	--	695	32
Ogdensburg, N.Y	--	--	89,500	4,794	--	--	--	--
Pembina, N. Dak	1,152	79	22,377	1,206	--	--	--	--
Philadelphia, Pa	--	--	--	--	120	8	819	56
Portland, Maine	3,087	167	14,157	813	--	--	--	--
Portland, Oreg	--	--	--	--	148	10	103	7
St. Albans, Vt	84	3	36,205	1,923	--	--	--	--
San Francisco, Calif	--	--	--	--	49	3	318	20
San Juan, P.R	--	--	--	--	--	--	1,000	69
Savannah, Ga	--	--	--	--	--	--	127	7
Seattle, Wash	19	1	48,428	3,177	--	--	--	--
Tampa, Fla	--	--	--	--	367	24	2,855	143
Total	4,718	271	301,887	17,475	1,104	66	15,012	870

WORLD REVIEW

World production of peat in 1973 was estimated at 106 million short tons, 8% less than the revised output reported for 1972.

The U.S.S.R. was by far the largest peat producer with an estimated 90% of the world production. According to published U.S.S.R. figures, 30 million tons of peat was produced by State enterprises for agricultural use, and an estimated 66 million tons was produced for fuel. Agricultural peat was used for general soil improvement and the manufacture of fertilizers, and fuel peat was used for generating electric power and for domestic and industrial heating.

Ireland ranked second in peat production with an estimated output of 6 million short tons. Virtually all of Ireland's production was fuel peat that was used for generating electric power and for heating households. A small amount of agricultural peat was produced, principally, for export.

West Germany, the third-ranking peat producer with 1.9 million short tons, provided about 2% of the world output. Most of the West German production was agricultural peat, with less than one-fifth consumed as a fuel.

Other producers ranking in output in the order named were the United States, the Netherlands, Finland, and Canada. The combined output of these countries was, however, only 2% of the total. Although fourth in world production, output of the United States was only 0.6% of the world total.

Table 10.—Peat: World production by country

(Thousand short tons)

Country [1]	1971	1972	1973 [p]
Argentina, agricultural use	4	7	11
Canada, agricultural use	[r] 337	376	390
Denmark, fuel [e]	6	6	6
Finland:			
Agricultural use	259	140	265
Fuel	112	166	171
France, agricultural use	85	117	[e] 121
Germany, West:			
Agricultural use	[r] 1,493	1,548	[e] 1,640
Fuel	352	313	308
Hungary, agricultural use [e]	72	72	72
Ireland:			
Agricultural use	63	[e] 70	[e] 70
Fuel	6,058	[r] [e] 6,000	[e] 6,000
Israel, agricultural use [e]	22	22	22
Japan [e]	80	80	80
Korea, Republic of, agricultural use	4	4	[e] 4
Netherlands [e]	440	440	440
Norway:			
Agricultural use	17	[r] [e] 20	[e] 20
Fuel	6	[e] 6	[e] 6
Poland:			
Agricultural use [e] }	55	55	40
Fuel [e] }			10
Spain	20	[r] [e] 20	[e] 20
Sweden:			
Agricultural use	[r] 125	115	[e] 110
Fuel	33	36	[e] 40
U.S.S.R.:			
Agricultural use [e]	30,000	30,000	30,000
Fuel	[r] 59,855	75,839	[e] 66,000
United States, agricultural use	605	577	635
Total	[r] 100,103	116,029	106,481
Fuel peat included in total	[r] 66,422	82,366	72,541

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition to the countries listed, Austria, Canada, Iceland and Italy produce a negligible quantity of fuel peat. No data are available for East Germany, a major producer.

TECHNOLOGY

Experimental research conducted at the University of Sherbrooke, Quebec, Canada,[3] indicated that peat moss, being a highly porous material, can be used as an adsorbing agent for the treatment of polluted water. In one study, moss peat was tested for its adsorbing power for beef extract and an alkyl benzene sulphonate (ABS) solution, contaminants sometimes found in municipally polluted water. Studies on the effects of time of contact, particle size, and concentration of pollutants in adsorption revealed a chemical oxygen demand (COD) reduction of around 27% for beef extract, and 72% to 95% for the ABS solution. The proposed water treatment process would filter polluted water through columns of peat moss to produce a relatively clean water. The peat then, if not toxic, could be used as a fertilizer, formed into building materials, or dewatered and burned.

Field and laboratory studies, also conducted by the University of Sherbrooke[4] have shown that peat moss can be used as an absorbing agent for oil recovery. Laboratory measurements indicate that peat moss has a stronger affinity for oil than straw, the absorbent presently being used for oil spill cleanup. Tests proved that peat moss, because of its highly porous and fibrous nature, can absorb up to eight times its own weight in oil. Field experiments were conducted at actual oil spill sites where, it was found, that peat moss spread before a vertically placed screen, acting as a boom, would easily stop an oil patch. Field tests also proved peat moss to be effective in beach cleanup when, spread on the beach and picked up with rakes, it removed at least 95% of the oil. It is indicated from field and laboratory studies that peat moss is a very effective absorbent for oil cleanup.

Additional research work at the University of Sherbrooke[5] evaluated the use of peat as a building material. Peat, when mixed with portland or other cements, produces a lightweight concrete, which is a good thermal and sound insulator. Through research, a process was developed for fabricating a material called peatcrete. Peatcrete is produced by first screening the peat through a No. 4 seive for better cohesion, then mixing with the cement. The best cement, water, peat mixture was found to be 1:2:2. After mixing, the peat/cement mixture was compacted into cylinders under a pressure of 18 pounds per square inch for 24 hours, after which the cylinders were dried at a temperature of 120° F. for 7 days. The resulting peatcrete had a compressive strength of 250 pounds per square inch and was very light, having a specific gravity of between 0.05 and 0.07. The peatcrete was cohesive enough to be sawed, drilled, nailed, and otherwise worked without disintegrating or splitting. Research is continuing into the development of industrial fabrication of peat-cement panels.

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[3] Tinh, V. Q., R. Leblanc, J. M. Janssens, and M. Ruel. Peat Moss—A Natural Adsorping Agent for the Treatment of Polluted Water. Can. Min. and Met. Bull., Montreal, Canada. V. 64, March 1971, pp. 99–104.

[4] D'Hennezel, F., and B. Coupal. Peat Moss—A Natural Absorbent for Oil Spills. Can. Min. and Met. Bull., Montreal, Canada. V. 65, January 1972, pp. 51–53.

[5] Oliver, R. Peatcrete. Eng. J., Montreal, Canada, V. 54, November 1971, pp. 25–27.

Perlite

By Arthur C. Meisinger [1]

The quantity of crude perlite sold or used in 1973 fell short of the record 545,000 tons established in 1972; however, the 544,000 tons sold or used in 1973 was obtained from a record quantity of 759,000 tons of crude perlite mined. Value of crude perlite sold or used in 1973 was 10% less than the record value set in 1972.

Compared with 1972 production, expanded perlite was produced at six fewer plants, but the quantities produced and sold or used declined only 3,000 tons and 3,500 tons, respectively. The value of expanded perlite ($28.0 million) in 1973 was also just under the record total of $28.4 million set in 1972. New Mexico and Illinois continued to be the leading States in production of crude and expanded perlite, respectively.

Table 1.—Crude and expanded perlite produced and sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Crude perlite						Expanded perlite		
	Quantity mined	Sold		Used at own plant to make expanded material		Total quantity sold and used	Quantity produced	Sold or used	
		Quantity	Value	Quantity	Value			Quantity	Value
1969	613	205	2,087	266	3,013	471	405	402	22,100
1970	607	176	2,056	280	2,848	456	420	416	24,972
1971	495	175	2,062	257	2,879	432	389	385	23,156
1972	649	224	2,540	321	3,691	545	427	421	r 28,397
1973	759	238	2,771	306	2,819	544	424	418	28,005

r Revised.

DOMESTIC PRODUCTION

Production of crude perlite in 1973 was reported by 11 companies in 7 States. Twelve mines were in operation compared with 13 mines in 1972. A record quantity (759,000 tons) of crude perlite was mined and surpassed the previous record quantity of 1972 by 110,000 tons. New Mexico continued to be the principal producing State with 89% of the U.S. crude perlite mined. Other producing States, in descending order, were Arizona, California, Nevada, Colorado, Idaho, and Texas.

The quantity of crude perlite sold or used to make expanded perlite products in 1973 was only 911 tons under the record total of 545,000 tons established the previous year. Value of crude perlite sold or used, however, declined 10% from the record value of $6.2 million in 1972.

Crude perlite was expanded at 76 plants in 30 States in 1973. The quantity of expanded perlite produced was 424,000 tons, compared with 427,000 tons in 1972. The value of expanded perlite also declined slightly from the record 1972 value of $28.4 million; value of expanded perlite sold and used in 1973 was $28.0 million.

The leading State in production of expanded perlite was Illinois. Other States with significant production in 1973 were California, Colorado, Florida, Indiana, Kentucky, Mississippi, New Jersey, Pennsylvania, and Texas.

[1] Industry economist, Division of Nonmetallic Minerals—Mineral Supply.

Table 2.—Expanded perlite produced and sold by producers in the United States

State	1972				1973			
	Quantity produced (short tons)	Sold or used			Quantity produced (short tons)	Sold or used		
		Quantity (short tons)	Value (thousands)	Average value per ton		Quantity (short tons)	Value (thousands)	Average value per ton
California	21,227	21,221	$1,827	$86.12	24,442	23,652	$2,071	$87.54
Florida	19,124	18,249	1,001	54.84	23,378	22,613	1,287	56.92
Indiana	14,866	16,331	968	59.27	14,878	14,801	1,021	69.01
Kansas	767	767	59	76.71	900	893	97	108.87
Maryland	(1)	3,208	299	93.22	(1)	(1)	(1)	(1)
Missouri	(1)	(1)	(1)	(1)	3,930	3,930	362	92.24
New York	5,739	5,739	469	81.76	6,526	6,128	495	80.70
Ohio	12,791	12,791	774	60.52	12,099	12,099	748	61.85
Pennsylvania	29,231	29,790	1,667	55.97	36,490	35,230	2,055	58.33
Texas	21,696	21,210	1,270	59.87	18,273	18,452	1,210	65.57
Other States [2]	r 301,128	r 292,033	r 20,063	r 68.70	282,646	280,053	18,659	66.63
Total	426,569	421,339	r 28,397	r 67.40	423,562	417,851	28,005	67.02

r Revised.
[1] Included with "Other States."
[2] Includes Colorado, Georgia, Idaho, Illinois, Iowa, Kentucky, Louisiana, Maine, Maryland (1972 quantity produced only and 1973), Massachusetts, Michigan, Minnesota, Mississippi, Missouri (1972), Nebraska, Nevada, New Hampshire, New Jersey, Oregon, Tennessee, Utah, and Wisconsin.

CONSUMPTION AND USES

Domestic consumption of expanded perlite was nearly 417,800 tons in 1973—only 3,500 tons below the record 421,300 tons consumed in 1972. The percent disposition of expanded perlite in the United States is shown in table 3. Filter aid, plaster and concrete aggregates, formed products, and insulation board (included with "Other" uses) were the principal domestic uses of expanded perlite. Compared with that of 1972, use of expanded perlite in filter aids increased 3%, and use in horticultural aggregates increased 2%. Decreases in expanded perlite for plaster aggregate, concrete aggregate, and low-temperature insulation were 2%, 1%, and 2%, respectively. Other uses totaled 46% and included primarily insulation board, and lesser uses such as paint textures, foundry castables and bonding agents, polishing compounds, and miscellaneous industrial and agricultural products.

Table 3.—End use of expanded perlite

(Percent)

Use	1972	1973
Filter aid	16	19
Plater aggregate	12	10
Concrete aggregate	8	7
Horticulture aggregate	3	5
Low-temperature insulation	4	2
Masonry and cavity fill insulation	(1)	1
Fillers	(2)	2
Formed products	(2)	8
Other [3]	57	46

[1] Less than 1%.
[2] Included with "Other" to avoid disclosing individual company confidential data.
[3] Includes insulation board.

PRICES

Producers sold crushed, cleaned, and sized crude perlite to expanding plants at an average price of $11.64 per short ton in 1973, and the portion used by producers in their own expanding plants was valued at an average of $9.21 per ton. The weighted average of both categories was $10.28 per ton—a decrease of $1.16 from the 1972 price.

Expanded perlite sold or used, according to expanders, had an average value of $67.02 compared with $67.40 per ton in 1972. However, average values by States in 1973 ranged from $34 to $151 per ton.

WORLD REVIEW

Greece.—Data on perlite production in 1973 were not available; however, the quantity of crude perlite produced in 1972 was approximately 136,500 tons—a decrease of 20% from the 171,300 tons (revised) reported in 1971. Although crude perlite production in Greece declined in 1972 for the second consecutive year, the quantity of perlite screened and sized (120,300 tons) in 1972 for export increased over that (104,500 tons) produced in 1971.

The country's largest perlite producer, Silver and Barytes Ores Mining Co., Athens, announced plans to enlarge its perlite facilities on the island of Milos with the construction of a new crushing and screening plant at Vouthia Bay. The current plant has a capacity of about 150,000 tons per year. The new plant is expected to increase graded perlite capacity to around 350,000 tons per year by 1975. Crude perlite reserves of Silver and Barytes Ores on Milos was estimated to be 150 million tons.[2] The company also has a small perlite-expanding plant (2,000 tons per year) in Athens that largely supplies expanded perlite for markets in Greece.

Other producers of crude perlite in Greece are N. Buras and Co. with deposits on Kos, and L. K. Sarides Mining Enterprises S. A. The latter company started mining on Milos in 1972 and reportedly shipped 7,000 tons of crude perlite in 1973.[3] The company's mines are at Tsigrado and Vounalia.

Hungary.—Production of crude perlite in Hungary was last reported in 1971 as 67,100 tons. No data were available for 1973, but production has probably averaged 70,000 tons or better for the last 2 years. Production estimates were based on increasing exports and research interest by Hungary in developing new uses for expanded perlite.

Crude perlite from the open pit mine at Pálháza, northern Hungary, was preheated and mixed with bitumen at the Tapolca insulation material plant in 1973. The new insulation product (bituminous perlite) is reportedly resistant to decay and bacterial attack. The plant's production in 1973 was about 247,000 cubic feet.[4]

The Research Institute of the Silicate Industry in Hungary announced a process to produce foam-glass granules from ground crude perlite. The process, using conventional foam-glass techniques, produces a material that has a vesicular structure with high internal strength and low permeability. The foam-glass perlite granules, properly mixed with portland cement and water, reportedly produced an unusually strong lightweight insulation concrete. These lightweight concretes are commercially attractive because the lower permeability of foam-glass perlite granules, compared with expanded perlite, requires less water and up to 30% less cement in formulating.

Also in 1973, a new horticultural use of expanded perlite for propagating tree saplings was developed jointly by the Hungarian Perlite Institute and the Department of Forestry, Budapest University, Budapest, Hungary. The method consists of forming cold beds, about 5 feet wide and 1 to 1½ feet deep, that are filled with an 8- to 10-inch layer of perlite kept moist and enriched with a chemical fertilizer. Each 10.8-square-foot area of the perlite beds is reported to have the capacity of raising up to 2,200 seedbed plants.[5]

Philippines.—The quantity of crude perlite mined by the Trinity Lodge Mining Corp. in 1973 was 909 tons, and represented a substantial increase over that produced in 1972.

Turkey.—Approximately 19,100 tons of crude perlite was produced in 1973, 43% less than the 33,500 tons produced in 1972. Producers and/or expanders of perlite in Turkey are Pabalk Ticaret Limited, Sirketi, Istanbul; Elyafli Çimento Sanayii ve Ticaret, A.S., Istanbul; and Etibank General Management, Ankara.

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[2] Industrial Minerals. Greece. A Wealth of Industrial Minerals. No. 75, December 1973, p. 49.
[3] Industrial Minerals. Greece. A Wealth of Industrial Minerals. No. 75, December 1973, p. 29.
[4] Industrial Minerals. Company News and Mineral Notes. No. 75, December 1973, p. 67.
[5] Rock Products. International Report. V. 77, No. 2, February 1974, p. 88.

Crude Petroleum and Petroleum Products

By David A. Carleton,[1] William B. Harper,[2] Bernadette Michalski,[2] and Betty M. Moore [3]

CONTENTS

The United States petroleum industry experienced considerable change and development during 1973, occasioned by additional government involvement and a growing awareness among the public of petroleum industry dynamics. Principal events were the decline in U.S. liquid hydrocarbon production, widespread petroleum product shortages, dwindling inventories, an embargo by some Arab countries on exports to the United States, and substantial price increases. Government activities involved cessation of the mandatory import controls, decontrolling prices, establishing a two-tier pricing system, creating new allocation programs, adopting a new license-fee system to replace import duties, and the issuance of consumption-constraining legislation.

Crude oil production (including lease condensate), which totaled 9.2 million barrels per day (bpd) in 1973, was the lowest since 1968 and 3% lower than that of 1972. The decline resulted from the exhaustion of older fields and the absence of discoveries of new fields. At yearend, final permission was given to construct the Alaska pipeline. When completed, the line will permit production on the North Slope to increase initially by an estimated 600,000 bpd.

Domestic demand for petroleum products, which increased 5.4% during the year, was inhibited during late 1973, particularly by shortages and by conservation efforts. This was the second lowest rate of increase since 1964 reflecting, also, unusually warm winter weather. Domestic demand for refined products, which averaged 17.3 million bpd, might have fallen considerably short of this level had not demand been stimulated in early 1973 by the continued conversion of powerplants from high-sulfur coal use to low-sulfur residual fuel oil use. Further-

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[2] Mineral industry specialist, (Petroleum) Division of Fossil Fuels—Mineral Supply.
[3] Statistical assistant, Division of Fossil Fuels—Mineral Supply.

more, demand was up because of the substitution of petroleum products for a curtailed use of natural gas. In addition there were higher than normal additions to motor gasoline inventories, both at secondary levels and at the consumer storage level.[4]

The decline in domestic production of liquid hydrocarbons in 1973 made it necessary to meet with imports the rising demand for petroleum products. Imports which totaled 6.2 million bpd, a 30% increase from 1972 levels, consisted of about one-half crude oil and one-half finished and unfinished products. The Western Hemisphere continued as the principal source of imported oil, providing nearly two-thirds of the total.

Inventories of liquid hydrocarbons at primary storage facilities were well below those of 1972 untii near yearend, and throughout most of the year stock levels were of concern. At yearend 1973, however, stocks were equivalent to 58 days of domestic demand or virtually the same as a year earlier. It should be noted that roughly 20% to 30% of these stocks are either tank bottoms or pipeline fill, or are in other equipment in order to assure continuous operations, and are therefore unavailable for shipment.

The lone Federal offshore lease sale took place off Mississippi, Alabama, and Florida on December 20. Total high bids for the sale reached $1.5 billion as companies placed 373 bids on 89 of the 147 tracts available for leasing. The U.S. Department of the Interior also announced that it established lease-sale boundaries containing, for future sale, 6 million acres offshore California. Interior also announced that it plans to speed-up lease sales in areas offshore Alaska, California, Texas, and Louisiana. The California State Lands Commission lifted the moratorium on new oil-well drilling on State-owned offshore land.

Geophysical and geological exploration increased in 1973 as the outlook for petroleum exploration improved over previous years. According to the Hughes Tool Co., an average of 1,373 rotary rigs were active in 1973, the highest since 1966. However, according to the American Petroleum Institute (API), there were 26,592 exploratory and development wells drilled during the year, down 2.6% from the 1972 figures. Factors causing this decline were weather, lack of steel, shortages of drilling crews, and economic conditions.

The API estimated that reserves of crude oil declined for the third consecutive year as production withdrawals continued to outstrip additions to reserves. Reserves of 35.3 billion barrels, at yearend 1973 represented a reserves-to-production ratio for crude oil of 11:1 based on 1973 production. The largest single additions to reserves occurred in 1970 when Alaska's North Slope discoveries were included for the first time. Since World War II, reserves-to-production ratios have trended downward from a high of 13.6:1 in 1949 and to a low of 9.2:1 in 1969.

Refinery throughput capacity at yearend 1973 amounted to 14.2 million barrels per (calendar) day, up 3% from yearend 1972. Following the early 1973 discontinuance of import quotas on crude oil and petroleum products, many refiners announced expansion plans that could have increased throughput capacity by nearly 1.5 million bpd by the end of 1976. Most of the proposed new capacity was scheduled to use imported crude oil. However, at the close of 1973 many of these plans and other longer range projects were either cancelled or suspended because of the uncertainties of supply, characterized by the Arab oil embargo during the latter part of the year. Output of refined products from U.S. refineries accounted for only 75% of total demand for refined petroleum products in 1973. Only 35% of residual fuel oil demand was met with domestic refinery output.

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[4] Certain terms as used in this chapter are more or less unique to the petroleum industry. Principal terms and their meaning are—

Total demand.—A derived figure representing total new supply plus decreases or minus increases in reported stocks. Because there are substantial secondary and consumers' stocks that are not reported to the Bureau of Mines this figure varies considerably from consumption.

Domestic demand.—Total demand less exports.

New supply of all oils.—The sum of crude oil production, plus production of natural gas liquids, plus benzol (coke-oven) used for motor fuel, hydrogen, and other hydrocarbons, plus imports of crude oil and other petroleum products.

Transfers.—Crude oil conveyed to fuel-oil stocks without processing, or reclassification of products from one product category to another.

All oils.—Crude petroleum, natural gas liquids, and their derivatives.

Exports.—Includes shipments to United States territories, possessions, and free trade zones.

Imports.—Includes receipts from United States territories, possessions, and free trade zones.

Table 1.—Salient statistics of crude petroleum, refined products, and natural gas liquids in the United States

(Thousand 42-gallon barrels unless otherwise indicated)

	1969	1970	1971	1972	1973 p
Crude petroleum:					
Domestic production (including lease condensate)	3,371,751	3,517,450	3,453,914	3,455,368	3,360,903
World production	r 15,222,511	r 16,718,708	17,662,793	18,600,501	20,560,852
U.S. proportion percent	22	21	20	19	17
Exports [1]	1,436	4,991	503	187	--
Imports [2]	514,114	483,293	613,417	811,135	1,183,996
Stocks, end of year	265,227	276,367	259,648	246,395	242,478
Runs to stills	3,879,605	3,967,503	4,087,809	4,280,863	4,537,254
Value of domestic product at wells:					
Total thousands	$10,426,680	$11,173,726	$11,692,998	$11,706,510	$13,057,905
Average per barrel	$3.09	$3.18	$3.39	$3.39	$3.89
Total producing oil wells Dec. 31	542,227	530,990	517,318	508,443	497,378
Total oil wells completed during year (successful wells)	14,368	13,020	11,858	11,306	9,902
Refined products:					
Exports [1]	83,449	89,467	81,342	81,202	83,515
Imports (including unfinished oils and plant condensate) [3]	641,437	764,769	819,463	924,179	1,079,527
Stocks, end of year [4]	656,344	675,502	695,878	712,584	765,829
Completed refineries, end of year	281	279	282	277	284
Daily crude-oil capacity	12,074	13,020	13,437	13,775	14,489
Natural gas liquids:					
Production	580,241	605,916	617,815	638,216	634,423
Stocks, end of year	58,552	65,992	88,421	79,238	94,106
All oils:					
Total disposition of primary supply	5,249,056	5,463,259	5,638,853	6,076,346	6,386,643
Exports	84,885	94,458	81,845	81,389	84,212
Total domestic demand for products (including crude-oil losses)	5,164,171	5,368,801	5,557,008	5,994,957	6,302,431

p Preliminary (except for crude production and value). r Revised.
[1] U. S. Department of Commerce data.
[2] Reported to the Bureau of Mines.
[3] U. S. Department of Commerce data, except for unfinished oils and plant condensate which are Bureau of Mines.
[4] Stocks of refined products also include stocks of unfinished oils, natural gasoline, plant condensate and isopentane.

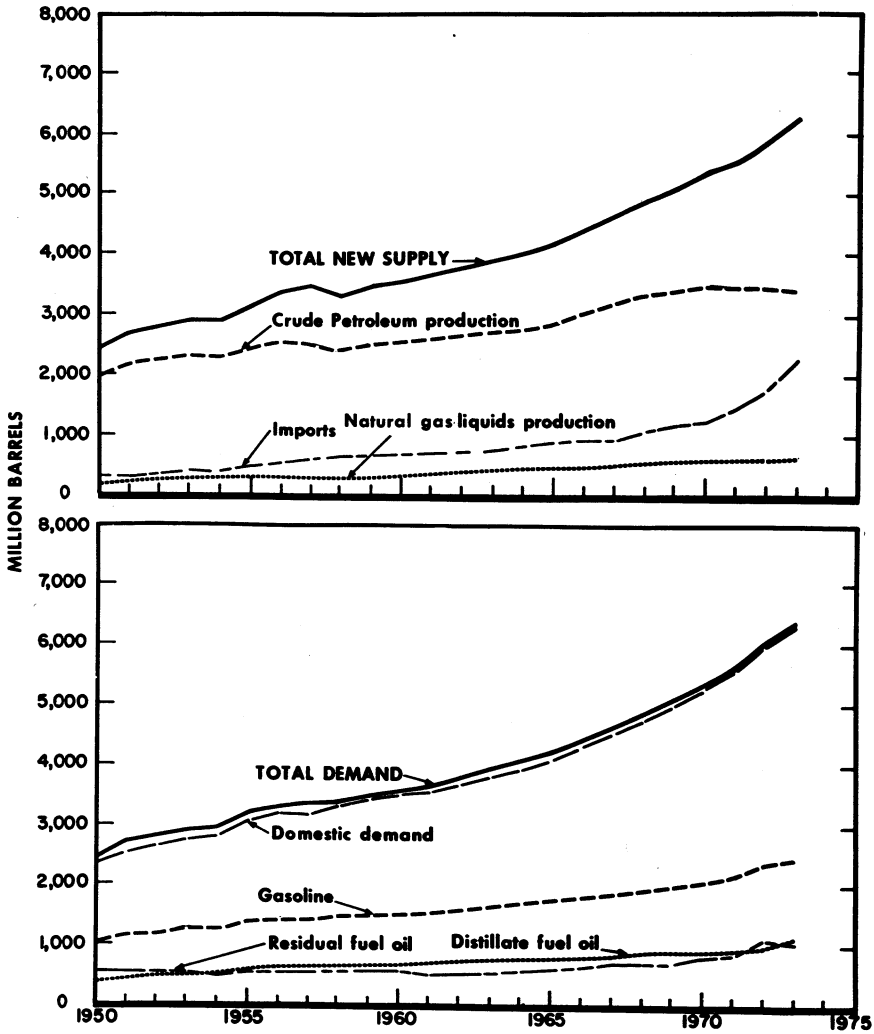


Figure 1.—Supply and demand of all oils in the United States.

CRUDE PETROLEUM

PRODUCTION

Production of crude oil (including lease condensate) declined again in 1973, after recovering slightly in 1972. Total production of 3.36 billion barrels, nearly 9.2 million bpd, 3.0% less than that of 1972. The decline occurred in 18 of the country's 31 producing States. Of these, Louisiana had the greatest loss, 165,214 bpd or down 6.8% from 1972. Others with less production were Oklahoma, 45,011 bpd (—7.9%); California, 29,992 bpd (—3.2%); New Mexico, 26,134 bpd (—8.6%); Texas, 19,216 bpd (—0.5%); Mississippi, 13,693 bpd (—8.2%); and Illinois, 11,521 bpd (—12.1%).

Florida was the only State that recorded significant production gains. Output, mostly from fields in the northwestern part of the

State, averaged 89,575 bpd, up 43,282 bpd or 93.5% from that of 1972. Others with increased production during the year were Utah, up 16,674 bpd (22.9%); Wyoming, 5,214 bpd (1.4%); Colorado, 12,534 bpd (14.3%); Alabama, 4,775 bpd (17.6%); and Michigan, 4,449 bpd (12.5%).

The general decline in output resulted from the exhaustion of many of the older fields, lagging secondary and tertiary programs and the paucity of large discoveries to reverse significantly the declining productive capacity.

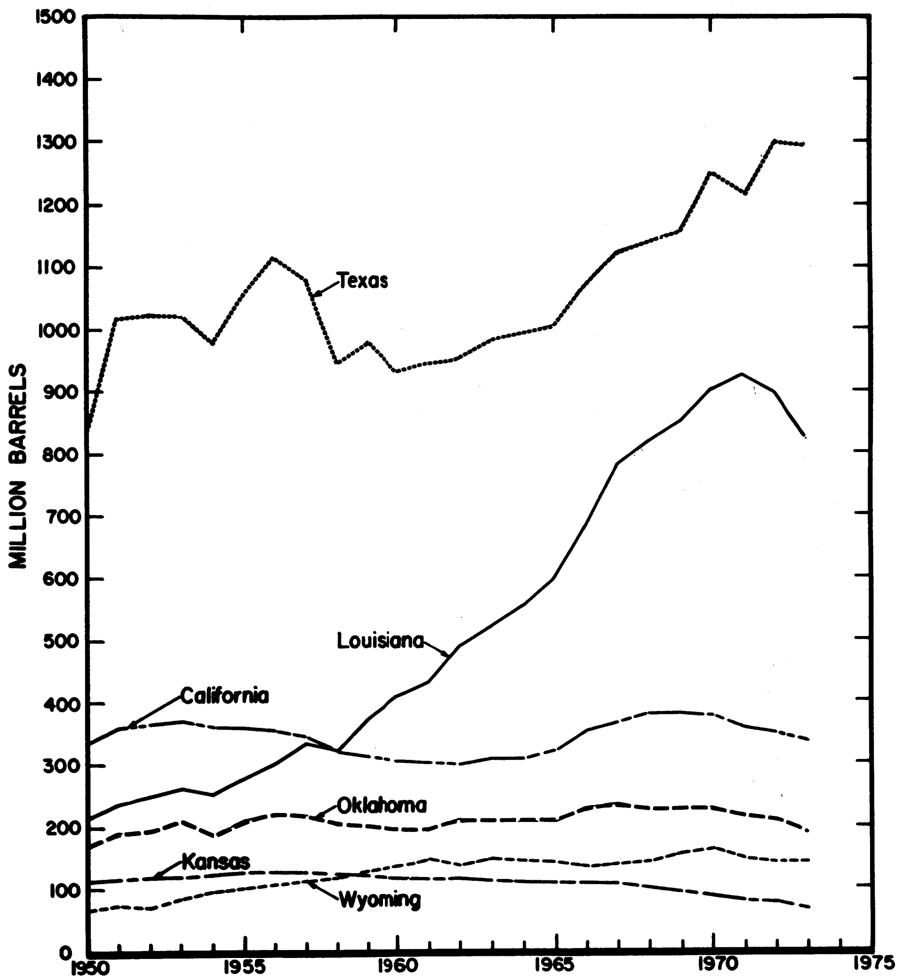


Figure 2.—Production of crude petroleum in the United States, by principal producing States.

CONSUMPTION

Refineries processed 4.5 billion barrels (12.4 million bpd) of crude oil, of which 74% was domestic crude and 26% was from foreign sources. The amount processed was 6% more than that refined in 1972 and represented 91.1% of the January 1, 1973, operable refining capacity of 13.6 million bpd. This was the second highest operating ratio in the past decade.

The highest average monthly operating

ratio was reached in June when 94.3% of the operable throughput capacity was in use. This was the highest monthly rate reached since December 1969 and the fourth highest in the past decade. Refinery input and operating ratios were at record levels during the spring of 1974, because of the summer motor gasoline shortage in 1973. Conversely, the ratio of input to operable capacity in December was among the lowest December operating ratios during the past decade. In December 1973 the government announced plans to allocate crude oil to all refiners at an input ratio of approximately 85% of throughput capacity, owing to the shortage resulting from the Arab embargo on oil shipments to the United States. These were scheduled for adaptation under the mandatory allocation program effective December 27.

PRODUCTIVE CAPACITY

According to the API the maximum crude oil output that could be attained in the United States as of January 1, 1974 was 9.7 million bpd. This was the lowest since 1960 and was 0.6 million bpd or 6% less than that on January 1, 1973. Texas and Louisiana suffered the greatest losses, declining a combined 0.3 million bpd. Colorado and Wyoming had the largest increases totaling 0.03 million bpd. These estimates were based on the assumption that such production could be achieved in 90 days with existing wells, well equipment, and present surface facilities, plus work changes that could be accomplished within that time. No productive capacity was credited to the North Slope of Alaska since there was no way to market the oil, and installation of producing and pipeline facilities were incomplete.

Although the United States had, for many years, a surplus productive capacity that could be called on to meet emergency needs, it became apparent in 1973 that the country no longer has an effective surplus capacity. Most of the surplus capacity is in fields in Eastern Texas.

DRILLING ACTIVITY

Although well completions were up in 1972 after several years of decline, well completions were down again in 1973. The success ratio improved, however, since 61% of the wells completed in 1973 yielded commercial quantities of either oil or gas, compared with 59% in 1972. In 1973, nearly 61% of the successful wells drilled were oil producers compared with 70% in 1972 and 88% in 1954. Of the States having considerable drilling activity, Ohio and California had the best success ratios, 89% and 78% respectively.

In December 1973, the California State Lands Commission ended a 4-year moratorium on new oil well drilling on State-owned offshore lands. The ban on offshore drilling was imposed after a well on federally leased land in the Santa Barbara Channel blew out on January 28, 1969. The lifting of the ban followed the completion of a report which emphasized that equipment and recovery systems not available in 1969 now made the possibility of a similar accident far less likely.

On December 20, the U.S. Department of the Interior held its lone 1973 offshore lease sale. Total high bids for the sale, which covered Federal lands off Mississippi, Alabama, and Florida reached $1.5 billion. Companies placed 373 bids on 89 of the 147 tracts available for leasing, exposing a total of $3.4 billion.

RESERVES

The API Committee on Petroleum Reserves estimated proved recoverable reserves of crude oil as of December 31, 1973, to be 35,300 million barrels, a decline of 1,039 million barrels for the year.

Gains in proved reserves were accomplished in seven States, led by New Mexico, which added 60 million barrels. Losses in proved reserves occurred in 19 States, in those States having significant reserves, the largest losses occurring in Louisiana (452 million barrels), Texas (387 million barrels), California (66 million barrels), and Kansas (52 million barrels).

According to API, indicated additional reserves from known reservoirs amounted to 5,144.4 million barrels. These are potentially available crude oil reserves in known reservoirs expected to respond to fluid injection and other improved recovery techniques. Most of the indicated additional reserves are in Texas (2,083.3 million barrels), California (1,506.6 million barrels), and New Mexico (319.5 million barrels).

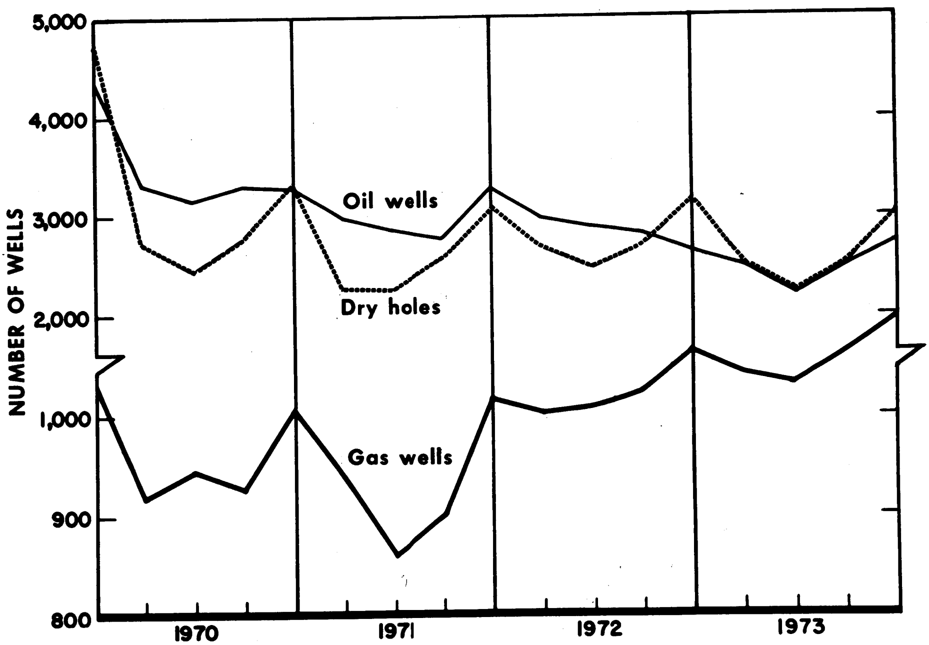


Figure 3.—Wells drilled for oil and gas in the United States, by quarters.

REFINED PRODUCTS

The Arab embargo enacted in October 1973 came too late to arrest a decided uptrend in oil consumption. As a result, domestic demand in 1973 was 17,254,000 bpd, a new record and 5.4% above the 16,367,000 bpd of 1972. Although crude oil production in 1973 was about 3% below the 1972 level, operable refining capacity expanded impressively from 13,641,000 bpd to 14,362,000 bpd, a net increase of 720,000 bpd, or 5.3%. About one-half of this increase in crude oil capacities occurred in refineries in Texas and Louisiana.

GASOLINE

Domestic demand for gasoline increased 4.3% in 1973, to 6,672,606 bpd. This rate was relatively high considering the conservation measures taken near the end of the year. During the first 10 months of 1973, demand increased 5.0%, somewhat less than that of the previous year. A factor affecting demand, especially in early 1973, was the building of secondary (unreported) inventories by many retailers, marketers and bulk consumers in anticipation of summer shortages. As a result stocks at primary (reported) storage terminals were at guarded levels as shown in table 36. In March, these stocks were equivalent to 32 days of demand, compared with 1971 when primary storage facilities held 42 days of demand in storage. Because of the shortages, refiners increased refinery yields of gasoline up to 48.4% of refinery runs in May and June. The previous 3-year average for these months was 45.5%. Ample supplies were available during the summer high-demand period prior to the Arab embargo. Since a greater proportion of automobiles in use have air-emissions-control equipment which reduces miles per gallon, the impact over the previous years' demand was less significant than that of other recent years. During December some service stations curtailed service hours and motorists formed lines at opened stations for restricted quantities of gasoline.

According to data compiled by API based on tax data reported by the States, 6,920,373 bpd of motor gasoline was consumed in the United States in 1973. This differs from demand compiled by the Bureau of Mines, which does not include changes in secondary stocks. At yearend the allocation level for each wholesale purchaser was 100% of requirements for certain priority uses such as energy production, emergency uses, agriculture, and transportation. Other businesses, such as industrial, commercial, governmental and social services agency users, were to receive 100% of 1972 consumption. There was also a 3% set aside for redirection by Federal Energy Administration (FEA).

Aviation gasoline demand in 1973 continued to decline. But the declining demand curve is leveling off since most air lines and air cargo carriers have completed programs for converting their fleets to jet-powered craft. The 1973 demand of 45,290 bpd was only 2.3% less than that of 1972.

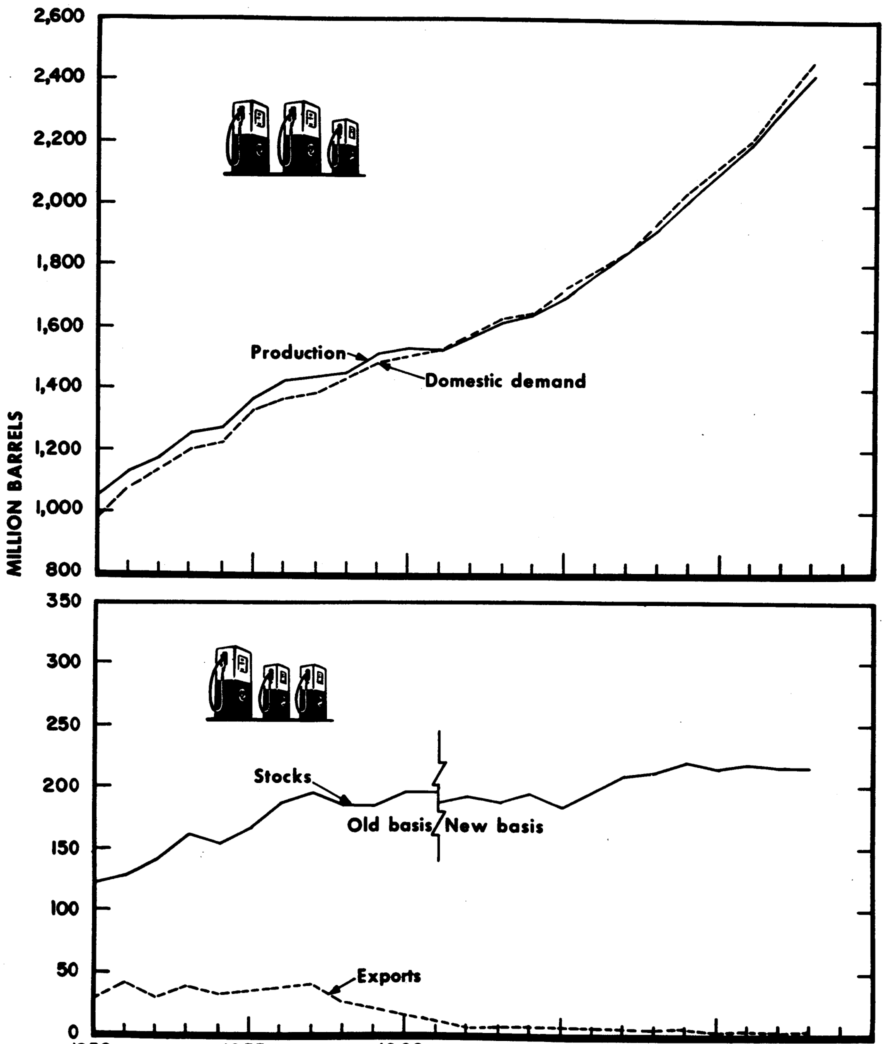


Figure 4.—Production, domestic demand, stocks, and exports of gasoline in the United States.

JET FUEL

By far the greatest use of kerosine is in commercial type jet fuel. This product, a kerosine with restrictions on content of aromatics and naphthenes, has a very low freezing point. The drastic cuts in commercial air lines flights, resulting from the Arab embargo on supplies of petroleum products, came too late to have any impact on the demand for commercial (kerosine) type jet fuel in 1973. Demand for this type averaged 833,247 bpd, a 3.5% increase over the volume used in 1972. The demand of 217,000 bpd, however, for naphtha-type jet fuel, used primarily by the military, was off 10.5% as a result of cutbacks in military flying.

Under the allocation program planned at yearend 1973, emergency flight operations and mercy missions were allotted 100% to 150% of 1972 volumes. The rules applied to both jet fuel and aviation gasoline users. Other users were to be curtailed as follows: Domestic air carriers (air lines), 95% of 1972 use; international air carriers, 100%; commercial and industrial users in general aircraft, 90%; military, 100% of requirements; personal pleasure and other, 70%. Bonded jet fuel users were excluded from the allocation program.

LIQUEFIED GASES, ETHANE, and ETHYLENE

Liquefied gases are derived from two sources. Those produced at refineries are called liquefied refinery gases to distinguish them from liquefied petroleum gases obtained by processing natural gas. The liquefied petroleum gases (LPG) are all parafins (propane, butane, and isobutane). The liquefied refinery gases (LRG) also contain parafins but may also contain unsaturates, that is, the olefins (propylene, butylene, ethylene, etc.). The parafins may be used as fuel including blending with motor gasoline or as feedstock at petrochemical plants. The olefins are used primarily as petrochemical feedstocks.

Demand for ethane (including ethylene) increased a substantial 12.5% in 1973. Use of ethane as petrochemical feedstock raised demand from 290,167 bpd in 1972 to 327,241 bpd in 1973 or an increase of 12.8%.

Domestic demand for LPG and LRG, excluding that blended into other products at refineries or terminals in 1973 was 1,120,866 bpd compared with 1,133,285 bpd in 1972. Nearly 78% of liquefied gas demand was propane. A series of events that occurred in 1972 led to considerable dislocation of the propane market in 1973. Price controls instituted in July 1972 froze the price that large companies (historic wholesale buyers) could pay for propane. Concomitantly, small companies (those with less than 30 employees) could purchase and sell propane without price constraints. As a result, the large companies found it difficult in early 1973 to bid successfully for propane. Furthermore, major natural gas consumers (industrial firms, electric powerplants, and natural gas utilities), fearing a shortage of natural gas, sought propane as a substitute or standby fuel and were active propane purchasers during the spring and summer. This represented a significant demand for propane and resulted in a major diversion of propane from established markets.

Because of the lower-than-normal midyear inventories and the prospect that residential and commercial consumers would not have adequate supplies during the 1973–74 winter, a mandatory propane allocation program was effected on October 3, 1973. This program was generally successful in that propane was available during the heating season; however, several factors had a moderating impact on demand. These included an unusually warm winter, conservation efforts, and resistance to sharply higher prices.

KEROSINE

Demand for kerosine continued to decline, falling 8.1% to 216,205 bpd. The principal use for kerosine was for space heating which represents 77% of domestic demand. Kerosine consumption is expected to continue the downtrend as consumers convert to more convenient forms of energy such as bottled (LPG) gas and electric power.

DISTILLATE FUEL OIL

Despite the warmest year in more than a decade, distillate fuel oil demand increased a moderate 5.5%. The heating degree-day average was about 9% warmer than normal. Although about 50% of the demand of 3,080,296 bpd was for heating, most of the gain over the 1972 level resulted from increased use at powerplants as a substitute for natural gas made unavailable and as an alternative for other fuels in areas where air quality standards restrict the use of high-sulfur content fuels. In some situations distillate fuel oil was used as a blend to reduce the sulfur-content of high-sulfur residual fuel oils. Gains in demand were also significant in the transport and industrial sectors as economic activity improved.

Mild weather, during the early part of the year, eased refinery pressure to maximize distillate fuel oil during the cold months. As a result the percentage yield of distillate fuel oil from the processing of crude oil, especially in March, April, and May were at the lowest levels in more than a decade.

Although stock levels, in terms of days demand, were at alarming low levels in January and February, inventories during the remainder of the year were at or above normal levels.

In October 1973, an Office of Petroleum Allocation was established to govern mandatory allocation of middle distillates including distillate fuel oil. In November it was announced that three categories of distillate fuel oil consumers were given preference in receiving adequate supplies: Farmers-ranchers, mass transit systems, and energy fuel producers.

RESIDUAL FUEL OIL

Residual fuel oil demand continued to be strong as a result of increasing use by electric utilities. Although some of the gain resulted from its use as a substitute fuel for curtailed supplies of natural gas, much of the increase was at new steam-powered plants and as a substitute for high-sulfur bituminous coal at certain locations. Residual fuel oil was able to fill the new market as the sulfur content continued to decline. The 1,437,250 bpd used by electric utilities accounted for 51% of the 2,794,340 bpd of residual fuel oil demand in 1973.

At refineries, the output of residual fuel oil with a sulfur content of less than 0.5% increased from 22.2% of total output in 1972 to 27.3% or 264,904 bpd. Low-sulfur (less than 0.5%) residual fuel oil imports also increased from 31.9% of total residual fuel oil imports or 555,019 bpd in 1972 to 36.6% or 669,277 bpd in 1973. Most of the increase in low-sulfur residual fuel oil came from Caribbean refineries (Venezuela, Netherlands Antilles, and Trinidad), which had recently installed desulfurization facilities, and from Italy, which refines a high proportion of low-sulfur North African crude oil.

A large share of the increase in demand was met by drawing on stocks. Throughout the year, stocks (at primary storage facilities) were at levels below all years since 1965 except 1970. At yearend 1973, these stocks were equivalent to 18 days of December demand. Residual fuel oil allocations established at the end of the year allocated 100% of requirements for priority users such as those engaged in energy production, essential commodities, marine shipping, and heating for health services. Industries were to receive 100% of 1973 consumption. Other space-heating consumers were to receive 100% of needs, but based on reductions of inside temperatures of 6° F for residences and 10° F for others.

ASPHALT AND ROAD OIL

Shipments of asphalt and asphaltic products in the United States in 1973 increased sharply from 31,121,000 short tons to 34,410,000 tons, or 10.6%. Shipments of paving asphalt experienced the sharpest boost increasing to 27,113,000 tons from 24,308,000 tons or 11.5%. Shipments of asphalt for roofing increased but at a slower pace; 6% in 1973 as compared with the spectacular jump of 22.6% in 1972. Production of asphalt in 1973, however, totaled 30,524,000 tons which was only 8% higher than the 28,235,000 tons produced in 1972. Hence it was necessary to make a net draw down on stocks in 1973 of 1,200,000 tons or 30.6%. Imports, likewise, decreased in 1973, from 1,684,000 tons to 1,535,000 tons or 8.9%.

Demand for road oil increased from 7,540,000 barrels in 1972 to 7,832,000 barrels in 1973, or nearly 4%, but production declined so that it was necessary to draw on stocks. These decreased by 38.8% in 1973. Trends in asphalt and road oil demand, as well as other data over a 5-year period, are available in table 48.

OTHER PRODUCTS

Petrochemical Feedstocks.—In addition to the liquefied gases and ethane supplied from natural gas processing, petroleum refineries supplied the petrochemical industry with 132,564,000 barrels of other feedstocks in 1973. This is an increase of nearly 6.9% over the volume supplied in 1972.

Exports increased 25.4% in 1973 to 5,801,000 barrels as shown in table 49.

Special Naphthas.—Special naphthas are used primarily for paint thinners, cleaning agents, and solvents. In 1973, domestic demand was 32,230,000 barrels, slightly higher than a year earlier when volume was 31,866,000 barrels. Exports increased 9.5% to 1,652,000 barrels.

Lubricants.—Demand for lubricants in domestic markets increased to 59,037,000 barrels or 11.8% in 1973, but these gains were modified by a 14.4% drop in exports, to 12.8 million barrels in 1973 from 14.7 million in 1972. As a result, the gains in overall demand in 1973 were modified to 6%.

Waxes.—Demand for wax strengthened in 1973. Production increased about 10% to 947,500 short tons and imports of wax more than tripled to 149,400 short tons. Exports of wax were lower by 23,100 tons or 14.6% but still sizeable at 135,100 tons, so it became necessary to draw on stocks to satisfy domestic needs. Domestic demand in 1973 was 971,700 short tons or up 28.3%.

The annual survey of wax sales made by the API represents 62% of total wax sales in the United States as reported by the Bureau of Mines. A breakdown of the 1973 annual sales of wax by end use in the United States compared with 1972 and 1971, is shown below in short tons:

Item	1971	1972	1973
Paper converting:			
Paper wrappers	93,660	95,678	114,655
Paperboard containers	130,193	122,905	128,999
Corrugated paperboard	71,816	78,163	70,782
Total	295,669	296,746	314,436
Candles, molded novelties, figurines, and decorative items	85,852	103,601	106,524
All other uses	180,216	196,702	180,271
Total reported	561,737	597,049	601,231

Source: American Petroleum Institute.

Petroleum Coke.—Petroleum coke production aggregated 132,290,000 barrels in 1973, a 10.5% increase over the preceding year. About 51%, or 67,527,000 barrels was marketable coke. Exports of marketable coke increased to 35,006,000 barrels or about 12.5%. About 26% of petroleum coke exports were destined for Japan, which received some 9,197,000 barrels in 1973, an increase of 10.7% from the 8,305,000 barrels of the preceding year. Canada participated in these increased exports, receiving 771,000 barrels more than in 1972. Exports to Belgium-Luxembourg increased 1,105,000 barrels or 32.7%.

Still Gas.—Still gas is a mixture of extremely low-boiling hydrocarbons produced during the distillation of crude oil, and may be used as refinery fuel and/or as a petrochemical feedstock. During 1973, refineries used 176,758 thousand barrels of still gas as fuel a 3.4% increase from the 170,993 thousand barrels consumed in 1972. Sizeable increases in the use of still gas occurred at refineries in Illinois, Oklahoma, and in Texas during 1973.

Increased use of still gas for refinery fuel had a noticeable impact on the consumption of still gas as petrochemical feedstock. In 1973, this usage fell to 12,428 thousand barrels or 15% below the 14,678 thousand barrels produced in 1972.

Unfinished Oils.—Unfinished oils are oils that have been partly refined and will be further processed by refiners; examples are unfinished naphtha, gas oil, virgin- or straight-run naphtha, topped crude, cracking stock, etc. All of these oils will be further processed by a refinery. The rerun (net of unfinished oils) represents the receipts of domestic or foreign oil plus or minus changes in stocks.

Miscellaneous Finished Oils.—The petroleum industry produces a variety of miscellaneous products that are sold directly to consumers or in bulk to specialty companies which package and distribute them under various trade names. Included in this category would be absorption oils, medicinal oils, insecticides, petrochemicals, and solvents. The domestic demand for these products in 1973 was 19,861,000 barrels.

TRANSPORTATION AND DISTRIBUTION

CRUDE OIL

A transportation system comprising pipelines, tankers, barges, tank cars, and to a lesser degree, tank trucks move crude petroleum to refineries for processing. Refineries received 72.9% crude oil requirements by pipeline, 25.8% by water, and 1.3% by tank cars and trucks in 1973.

The 17 States which comprise PAD district I accounted for 38.4% of the domestic demand for petroleum products. Refineries in District I, however, supplied only 16% of the demand. Foreign crude oil made up the lion's share 84%; 13% was from other PAD districts and 3% from within the district. Fifteen Midwestern States comprise PAD district II, the second largest consuming district. However, although a deficit producing and refining area, output of refineries in that district provided 78% of demand in 1973. About 27% of the crude oil processed in refineries in PAD district II was produced in that district, 45% was received from PAD district III, and 8% was from PAD district IV; 20% was imported from foreign sources. Both PAD districts III and IV produced and refined petroleum in excess of their demand requirements and thus helped meet the supply deficits of other districts.

Maps delineating PAD districts and Bureau of Mines refining districts are shown in figure 5.

Refined products produced at refineries in PAD district V in 1973 represented 93% of the domestic product demand for that district. Crude oil produced in District V supplied 57% of refinery input and foreign crude oil 41%; 2% was received from other PAD districts.

Data collected on receipts of domestic and foreign crude petroleum at refineries in the United States show receipts from local production (intrastate), receipts from other States (interstate), and receipts of imported crude. These data, by method of transportation, indicate the final receipts by water, pipeline, tank car, and truck. Receipts of domestic crude by water usually are moved by pipeline from the point of production to the point of water shipment. These data are shown in table 14.

Total receipts of crude oil at refineries in 1973 were 4,545.8 million barrels, or 12.4 million bpd, an increase of 266.6 million barrels or 730.4 thousand bpd for the year. Receipts from domestic sources, however, decreased 109 million barrels or 298.6 thousand bpd in 1973. Overland receipts of foreign crude oil (from Canada) were 52.9 million barrels higher in 1973 and foreign receipts from overseas sources increased 322.8 million barrels or 882.2 thousand bpd.

More foreign overseas crude oil entered refineries in all PAD districts in 1973 because domestic crude oil was in short supply. Refineries processed 4,537.3 million barrels of crude oil in 1973, reported a net of 1.9 million barrels used for refinery fuel and as losses, and added 6.6 million barrels to stocks as shown in table 34.

REFINED PRODUCTS

Domestic demand for petroleum products averaged 17,254,000 bpd in 1973, a gain of 5.4% above the 16,367,000 bpd for 1972. The demand broken down by PAD districts is as follows: District I, 6,628,000; district II, 4,649,000; district III, 3,199,000; district IV, 454,000; and district V, 2,324,000.

PAD district I imported an average of 2,358,000 bpd of refined petroleum products in 1973, and received 2,815,000 bpd from other districts. Shipments from PAD district I to PAD district II averaged 165,000 bpd, and 17,000 bpd of petroleum products were exported. PAD district II received an average of 857,000 bpd of refined products from other districts and imported 80,000. The district shipped 63,000 bpd to PAD district I and 73,000 bpd to PAD district III. District II also exported 9,000 bpd.

PAD district III shipped an average of 2,749,000 bpd of refined products to PAD district I, 670,500 bpd to district II, 30,000 bpd to district IV, and 66,000 bpd to district V. PAD district III also exported 103,000 bpd. The district received 73,000 bpd of refined products from district II and imported 123,000 bpd from foreign sources.

As compared with 1972 figures, imports of refined products from foreign sources almost tripled in 1973.

PAD district IV shipped an average of 93,000 bpd of refined petroleum products to other districts and received 55,000 bpd from other districts. District IV also imported 17,000 bpd.

PAD district V received an average of 66,000 bpd of refined products from PAD district III and 61,000 bpd from district IV. They also imported 140,000 bpd. District V shipped 3,000 bpd to PAD district I and 25,000 bpd to PAD district IV. Also, 100,000 bpd of refined products were exported from district V.

PIPELINES

The Bureau of Mines triennial pipeline survey covered pipeline statistics as of January 1, 1971, and the next survey will not be available until 1975. Meanwhile, Pipeline and Underground Utilities, a construction trade publication, estimates that 598 miles of crude oil lines were laid in 1973 as compared with 361 miles in 1972.

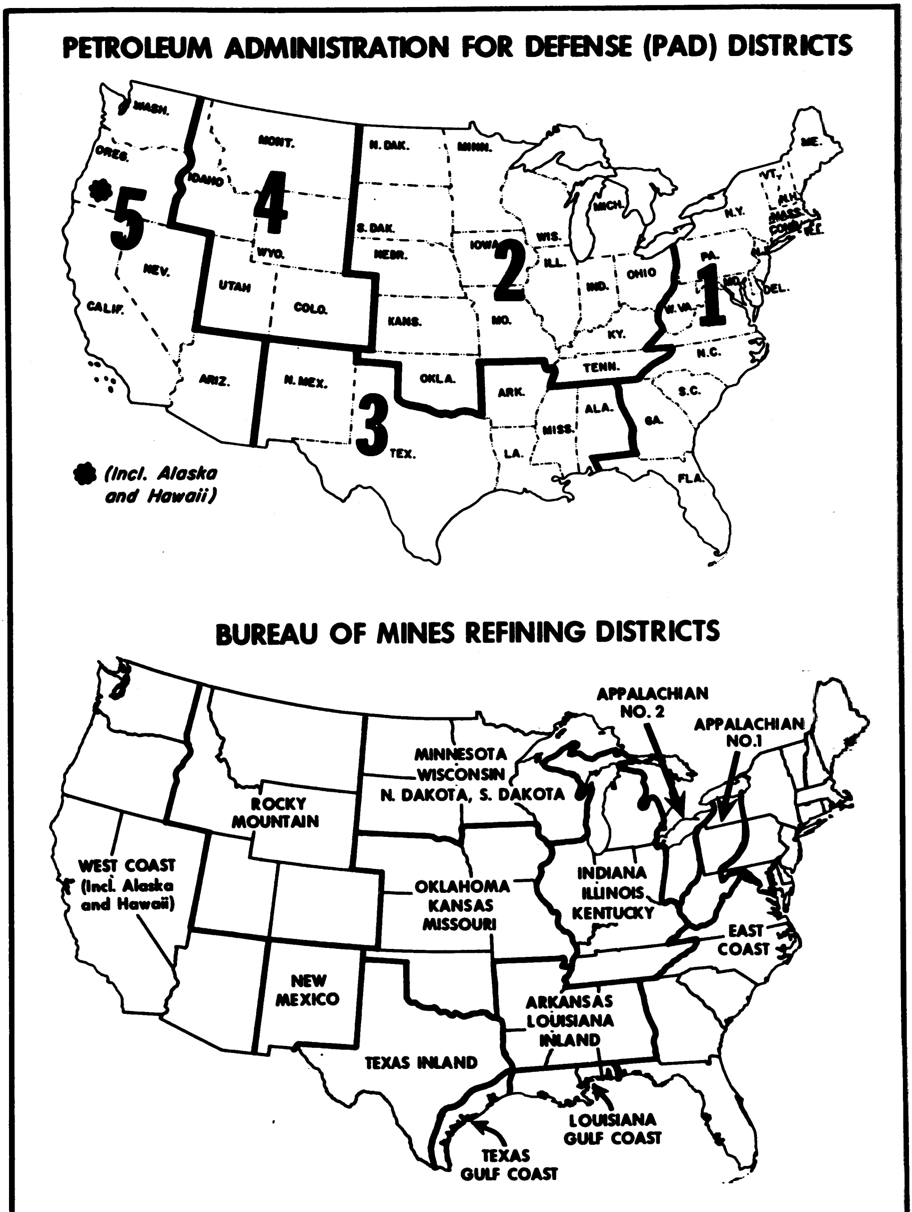


Figure 5.—Maps of Petroleum Administration for Defense (PAD) Districts, and Bureau of Mines Refining Districts.

Crude oil pipelines delivered 3,313.7 million barrels to refineries or 9,078,000 bpd in 1973, a slight increase over the 3,281.6 million barrels or 8,966,000 bpd in 1972, as indicated in table 14. Petroleum product pipelines delivered 3,204.9 million barrels or an average of 8,780,000 bpd in 1973, as compared with 2,967.9 million barrels or 8,109,000 bpd in 1972.

RAIL, TANK TRUCK, BARGE AND TANKERS

The annual survey of the Association of Oil Pipelines estimates that the total tonnage of crude and petroleum products carried was 1.8 billion short tons in 1972. Of this total, 47.53% was transported by pipelines, 23.14% by water carriers, 27.86% by motor carriers, and 1.47% by railroads. On an overall basis, volumes transported in 1972 were 7% greater than those in 1971. Petroleum products accounted for 65% of the volumes transported.

Product pipelines transport only the light products such as gasoline, light fuel oils and heating oils, liquid petroleum gas, kerosine, and jet fuel. These lines transported 1,199,710,500 short tons or 32.39% of the total. Motor carriers transported 462,500,000 or 38.55% of the petroleum products carried. In terms of billions of ton miles, the total aggregated 480.5 of which 40.5% was transported by pipelines and 52.9% by water carriers.

STOCKS

Stocks of all oils have been increasing steadily after touching a low point of 866.9 million barrels in February 1973. This inventory position was the lowest since February 1968, and close to the stock levels during the period when the 1967 Arab-Israeli conflict cut off imports from the Mideast. By the end of 1973, stocks of all oils had recovered to 1,008.3 million barrels or an increase of 49.3 million barrels over the inventory position at the end of 1972. Stocks of refined products were 47.1 million barrels higher at yearend 1973, and the improvement in the stock position in distillate accounted for 89.5% of the gains. Crude oil stocks shrunk from 279.5 million barrels in May of 1972 to a 7-year low of 235.4 million barrels in February 1973. Subsequently, there was some improvement in crude oil supplies throughout most of 1973, but a very sharp drop in crude oil imports in December caused stocks of crude to shrink to the lowest yearend levels since 1966. A drop in domestic production from 9.4 million barrels daily in 1972 to 9.2 million bpd in 1973, was also a contributing factor to the drop in stocks.

PRICES

Crude Oil.—As a result of the embargo by Arab nations of oil shipments to the United States, coupled with sharp rises in prices adopted by the Organization of Petroleum Exporting Countries (OPEC), there were large increases in crude oil and refined products prices in 1973. The uptrend continued in 1974. Six oil-producing countries in the Middle East announced in late December 1973 that they were more than doubling the price of crude oil to $11.651 cents per barrel from $5.11, effective the beginning of the new year. This was the second sharp increase since the price was raised from $3.01 per barrel to $5.11 or nearly 70% in October 1973.

On the domestic scene, the average price of crude oil at the wellhead, which was $3.39 per barrel in 1971 held at that level through 1972. However, in March 1973, the Cost of Living Council (CLC) granted an increase of $0.25 per barrel lifting the price to $3.64 per barrel. On May 15, 1973, the CLC allowed another $0.35 increase. Under phase 4 petroleum regulations, the ceiling price for crude oil was the posted price in each U.S. oilfield plus $0.35 per barrel. The average 1973 price was $3.89 per barrel, according to the Bureau of Mines.

On August 17, 1973, in an effort to stimulate production of domestic crude oil, the CLC enacted under phase 4 Oil Regulations a two-tier pricing system, releasing from ceiling prices "new oil", that is, oil produced above 1972 levels, plus an adjustment for the remainder of current production. The price of new oil produced, which was not covered by the price ceiling, rose steadily to market levels. The ceiling price for domestic crude was about $1 per barrel below the world price at the time phase 4 rules were issued on August 17. Since then, however, world prices have increased sharply and so have prices for new oil or exempt oil, that is, oil exempt from price controls. What constitutes "exempt oil" was broadened as of November 16, 1973, when the CLC exempted prices charged for the first sale of crude petroleum and petroleum condensates, including natural gas liquids produced from any stripper well lease. A "stripper well lease" is defined as a property[5] whose average daily production of crude petroleum, condensates, etc. did not exceed 10 barrels per day during the preceding calendar month.

The impact of exemption on new oil prices was felt almost immediately. Between October 30 and November 30, the price of new or exempt oil rose from an average $5.61 per barrel to $7.85, a jump of 40%. Between August 19 and the end of 1973, the price of new or exempt oil has more than doubled—from $4.05 to $8.70 per barrel and the trend has been upward since then. The prices for old oil, likewise, have been adjusted upward—from $4.05 on August 19, 1973, to $5.10 per barrel for an increase of 25.9% by the end of 1973. A comparison of 1972 prices with 1973 prices of various grades of crude oil is shown in table 28.

Refined Products.—With few exceptions, prices of most refined products in 1973 held close to the 1972 levels throughout the first 9 months. But when most of the OPEC nations raised crude oil prices 70% it was imperative for the CLC to act. In October 1973, the CLC drafted up new regulations. Price controls on refined products were eased under phase 4 to permit refiners, in part at least to pass-through increased costs on gasoline, home heating oil, and diesel fuels. Shown in the following tabulation (in dollars per 100 gallons) are some comparisons of prices in selected cities of No. 2 home heating oil between 1971 and 1973. Data for January 1974 are included to indicate the impact of the pass-through policy on retail prices.

[5] Definitions of "stripper wells" and "property" are available in detail in Title 6 Economic Stabilization, Section 150.54 of the Code of Federal Regulations.

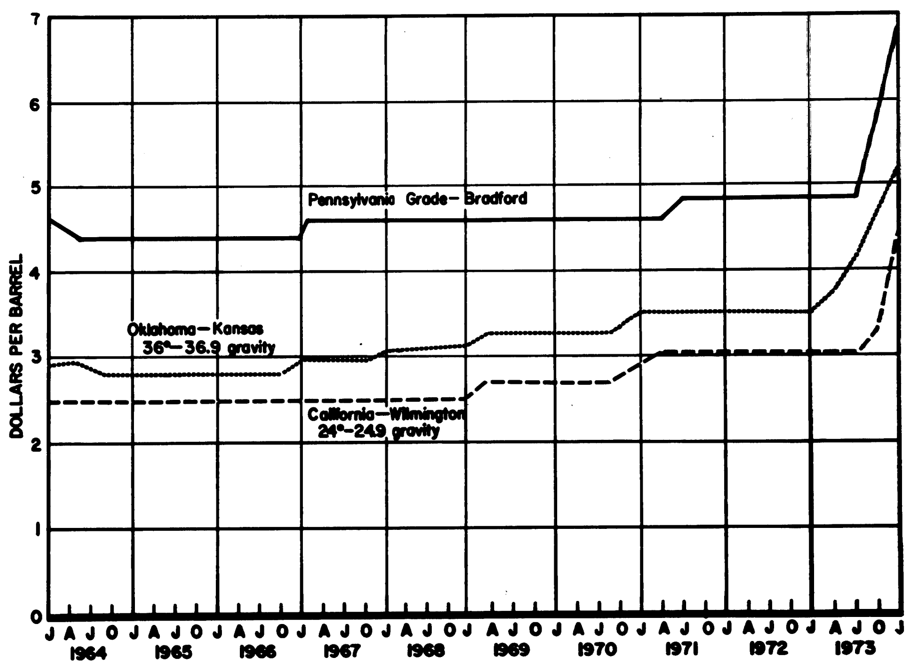


Figure 6.—Posted prices of selected grades of crude petroleum.

Standard metropolitan statistical areas	December 1971	December 1972	December 1973	January 1974
United States				
Average	$19.63	$19.72	$22.75	$32.89
Baltimore	19.23	19.33	26.64	31.18
Boston	20.47	20.40	30.44	32.90
Chicago-NW Indiana	18.42	18.66	27.01	31.66
Detroit	18.62	18.62	25.14	30.35
Milwaukee	18.85	18.93	27.85	31.23
Minneapolis-St. Paul	18.17	18.06	26.42	34.74
New York-NE New Jersey	20.32	20.40	33.41	36.90
Philadelphia	18.91	19.23	26.27	31.30
St. Louis	19.25	19.49	26.53	33.72
Washington, D.C.	19.73	19.78	29.95	33.30
Seattle	22.09	22.17	27.28	33.50

Source: Bureau of Labor Statistics.

Residual Fuel Oil Prices.—The price of Bunker "C" fuel oil at New York Harbor was depressed throughout 1972 but demand for tankers quickened and fuel oil prices stiffened. From $3.45 a barrel at the end of 1972, prices for Bunker "C" climbed steadily reaching $5.42 per barrel, a year to year increase of $1.97 or nearly 57%. The long-term trend of Bunker "C" prices 1964–73 inclusive is shown in figure 7.

Prices of gasoline in 1973 did not begin to rise until after OPEC action on crude in October, but from then on the climb was rapid. The average service station price of regular grade gasoline including taxes was 38.71 cents per gallon as of September 1. By December 1, the price had risen to 42.26 cents or 9% according to Platt's Oil Price Handbook and Oilmanac 1973.

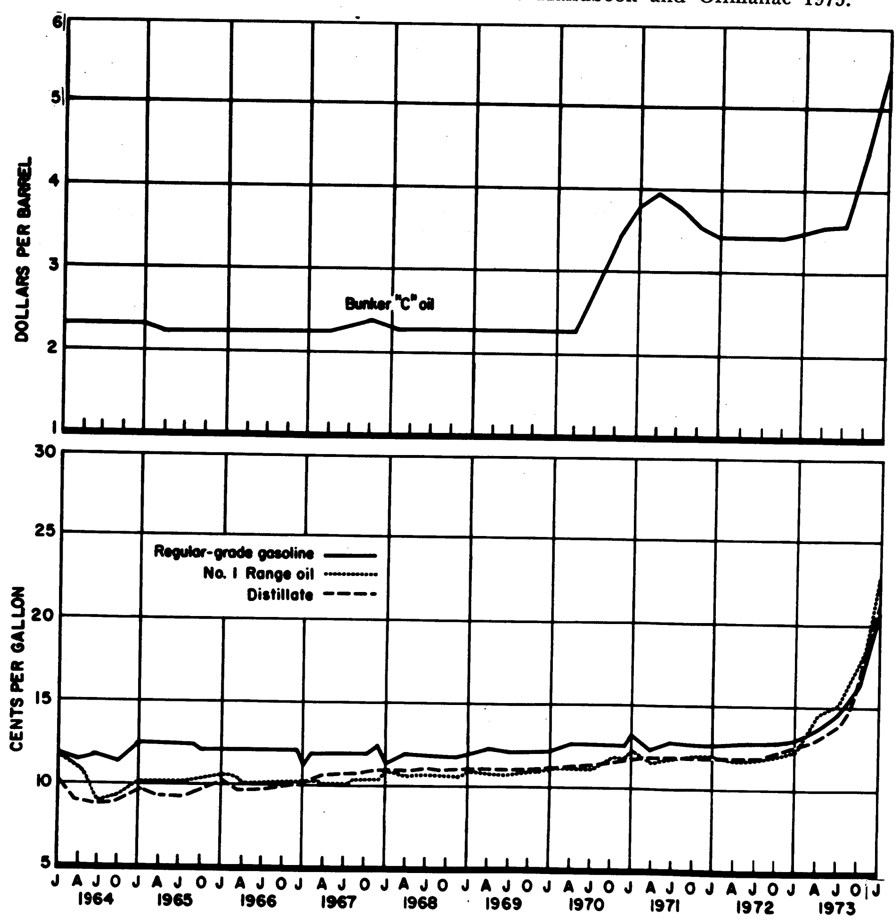


Figure 7.—Quarterly prices of Bunker "C" and No. 2 Distillate Fuel at New York Harbor; No. 1 Range oil at Chicago district, and regular grade gasoline at refineries in Oklahoma.

FOREIGN TRADE

Imports of crude oil and refined products aggregated 2,263.5 million barrels or 6.2 million bpd in 1973 for an overall 30.4% increase. The largest gain was in crude oil imports—372.9 million barrels, or 1.02 million bpd for a 46% increase. Imports of refined products were about 155.3 million barrels higher or 17% above 1973.

Crude oil imports totaled nearly 1,184 million barrels or 3.24 million bpd, and about 1 million bpd or 31% came from Canada as shown in table 58. Venezuela supplied 125.7 million barrels, or nearly one-fourth of the oil imported from Western Hemisphere countries. From the Eastern Hemisphere, nearly 651.8 million barrels or 55% of crude oil imports were obtained. Saudi Arabia supplied 168.5 million barrels, nearly all of which was received in the 10 months through October 1973. Nigeria supplied nearly as much (163.7 million barrels) of crude imports as Saudi Arabia. Refined product imports aggregated 1,079.5 million barrels or 2.96 million bpd, of which 34.4% of all products imported was residual fuel oil from Venezuela and the Netherlands Antilles. Distillate fuel oil imports in 1973 were more than double the volume received in 1972, reflecting the cessation of mandatory import controls. Distillate fuel oil imports from Central America and the Caribbean areas were almost double the 1972 volumes and most of the increases in 1973 originated in the Netherlands Antilles and the Virgin Islands. Imports of distillate from Europe increased almost fivefold, and exceeded those from South America by about 10 million barrels. Most of these increases originated in Italy and the Netherlands. Imports of motor gasoline nearly doubled with most of the increased supply originating in Canada, the Netherlands Antilles, Venezuela and the Virgin Islands. Europe became an important supplier of gasoline in 1973, and 1,122,000 barrels were imported from Turkey in 1973. Other comparisons of 1972 and 1973 imports are available in table 58. Included in the totals for imports of refined products were 3,076,000 barrels of jet fuels, 5,161,000 barrels of distillate fuel oil, and 43,447,000 barrels of residual fuel oil, which were withdrawn from bond for use as fuel for aircraft and vessels engaged in overseas commerce. These imports were exempted from tariff duties. Residual fuel oil imported by the military for offshore use in 1973 totaled 3,350,000 barrels or 33.5% less than the volume used in 1972.

Exports of refined products and crude oil in 1973 were up 2.8 million barrels, or 3.5% as shipments of gasoline, commercial type jet fuel, distillate fuel oil, and coke more than offset a drop in exports of liquefied petroleum gases, residual fuel oil, lubricants, and waxes. Coke accounts for 41.6% of exports from the United States and nearly one-half of this product was destined for Canada, Belgium, Italy, the Netherlands, and West Germany. Japan, however, was the largest single user of coke from the United States, accounting for more than 9 million barrels or nearly one-fourth of all the petroleum coke exported.

The tanker market in most of 1973 continued the uptrend which had begun in mid-1972. The single charter (spot) tanker market for dirty cargoes destined from Persian Gulf to U.S. Gulf climbed steadily and reached a high of 455 Worldscale or $48.96 per long ton, in mid-October 1973, the same month the Arab Embargo began. The impact of the embargo was immediate and demand for tankers shrunk drastically. As a result, the Worldscale tanker rate plummeted to 100, or to $10.68 per long ton in November. The rate then leveled off and by the end of 1973, Worldscale was at 110 or $11.75 per ton. Demand for tankers has since moderated and tanker rates resumed the decline. Average tanker costs, it should be noted, move slowly since they include charters running about 3 years. Also, much of the shipping moves in company-owned vessels.

NATIVE ASPHALT

Bituminous Limestone, Sandstone, and Gilsonite.—Natural rock asphalt and limestone rock asphalt were produced in Alabama, Missouri, and Texas and were used for road building material. Gilsonite was produced in Utah, and most was shipped to a refinery in Colorado and converted into petroleum products. The total production of native asphalts and related bitumens in 1973 was 2,088,657 short tons with a value of $8,464,000.

WORLD REVIEW

The outbreak of Arab-Israeli hostilities on October 6, 1973 created repercussions in world oil supplies. Production cutbacks among Arab producers and Arab embargoes on deliveries to the United States and the Netherlands converted Arab oil into an economic and political weapon.

Many developments in 1972 and early 1973 set an uneasy stage for the yearend crisis. Nationalization of foreign oil company holdings in Algeria, Iraq, Iran, Libya, and Nigeria and a multitude of participation agreements between state-owned companies and foreign operators caused a disruption in normal trading relations and resulted in higher market prices. Revision of the February 1971 Tehran agreement, which provided increases in posted prices through 1975, was under renegotiation in early October. However, by mid-October, negotiations were abandoned and the Persian Gulf States' governments chose to fix prices unilaterally. Libya and Nigeria soon joined the Persian Gulf States in this policy. The initial increases averaged 70%; however on January 1, 1974, posted prices were further raised to double the October 16 levels. Thus, the 1973 Saudi Arabian crude posted price opened at $2.591 per barrel, increasing to $3.011 per barrel by October 1, and increasing to $5.119 per barrel on October 16. The posted price for Saudi Arabian crude on January 1, 1974, was $11.651 per barrel.

The decision for a production cutback was reached in Kuwait on October 17 by the Organization of Arab Petroleum Exporting Countries (OAPEC). Most participants agreed to cut production by 5% (about 1 million bpd) from September production levels and by a further 5% each month until an Israeli "withdrawal is completed from all Arab territories occupied since June 1967 and that legal rights of Palestinians be restored." Military activities resulted in reduced Arabian crude exports even before the OAPEC meeting cutback decision. About ½ million barrels per day of crude had been cut from world markets when the Syrian ports of Baniyas and Tartus were closed because of war damages. A market loss averaging nearly another ½ million barrels per day was realized because hostilities delayed tanker loadings at Mediterranean terminals and Saudi Arabian crude flow through TAPline was reduced to minimize loss in the event of damage.

Crude imports from Arab nations constitute as much as 85% of European demand and 78% of Japanese demand, forcing these as well as all consuming nations to launch emergency petroleum conservation measures.

Although supply shortages and skyrocketing prices had serious effect on the economies of major consuming nations, the developing nations were especially hard hit since their foreign exchange reserves could not absorb higher energy prices placing their development in jeopardy.

Production.—World crude oil production increased by 10.5% over the 1972 level reaching an average production of 56.3 million bpd including an estimated 8.4 million bpd recovered from offshore operations. The United States remained the leading producer followed by the Soviet Union, Saudi Arabia, and Iran.

In spite of production cutbacks, output from the 12 Middle Eastern nations increased from 18.1 million bpd in 1972 to 21.7 million bpd or about 38% of total world crude production in 1973. Output from Saudi Arabia alone increased from 6.0 million bpd to 7.9 million bpd.

The three largest producing nations of North America contributed about 20% of total world crude output in 1973, or about 11.5 million bpd. Production increased in Canada and Mexico, offsetting most of the production decline in the United States.

Crude Oil Movements.—Crude oil movements to the major consuming markets of Western Europe, Japan, and the United States totaled more than 22 million bpd in 1973. European crude imports nearing an average of 14 million bpd were largely supplied by Middle Eastern countries, which provided 9.2 million bpd, an increase of 8.5 million bpd over 1972 levels. Saudi Arabia alone accounted for 3.6 million bpd up from 3.1 million bpd in 1972. Imports from Africa were estimated at 3.9 million bpd. About two-thirds of all African imports originated in Libya and Nigeria.

Japanese crude imports totaled 4.9 million barrels in 1973 up from 4.0 million barrels in the previous year. More than three-quarters of crude imports were obtained from the Middle East with Iran

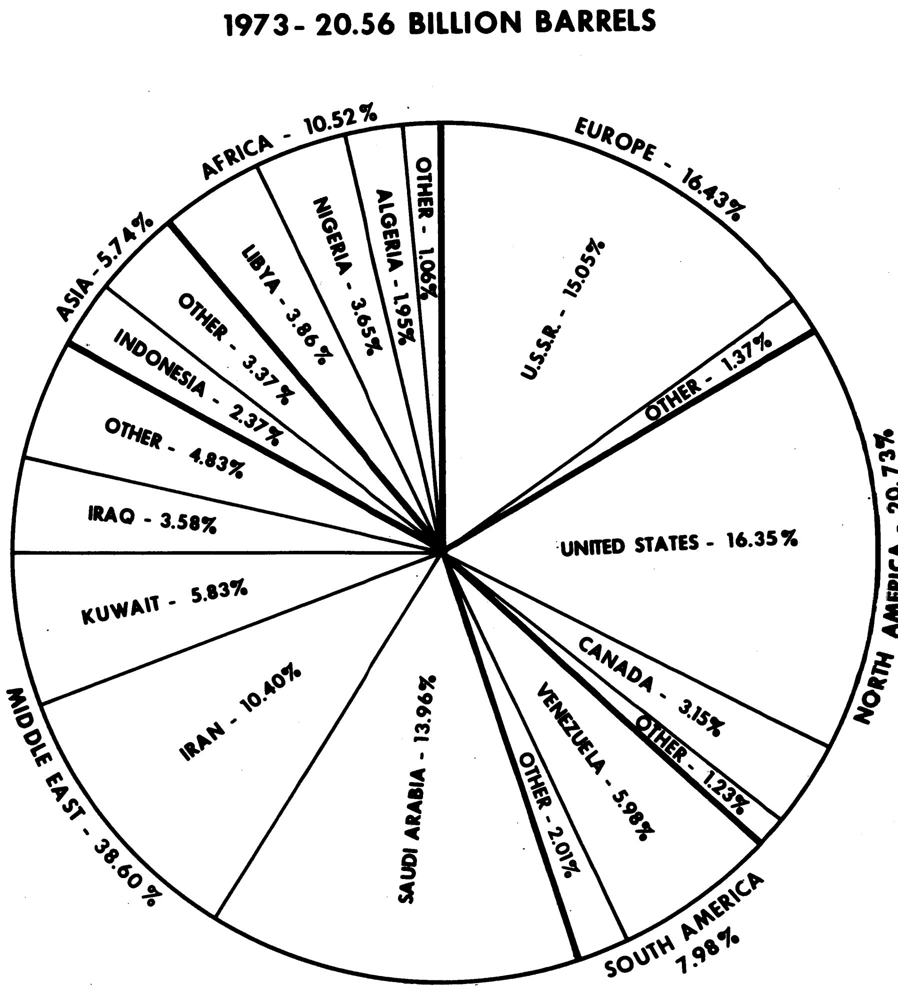
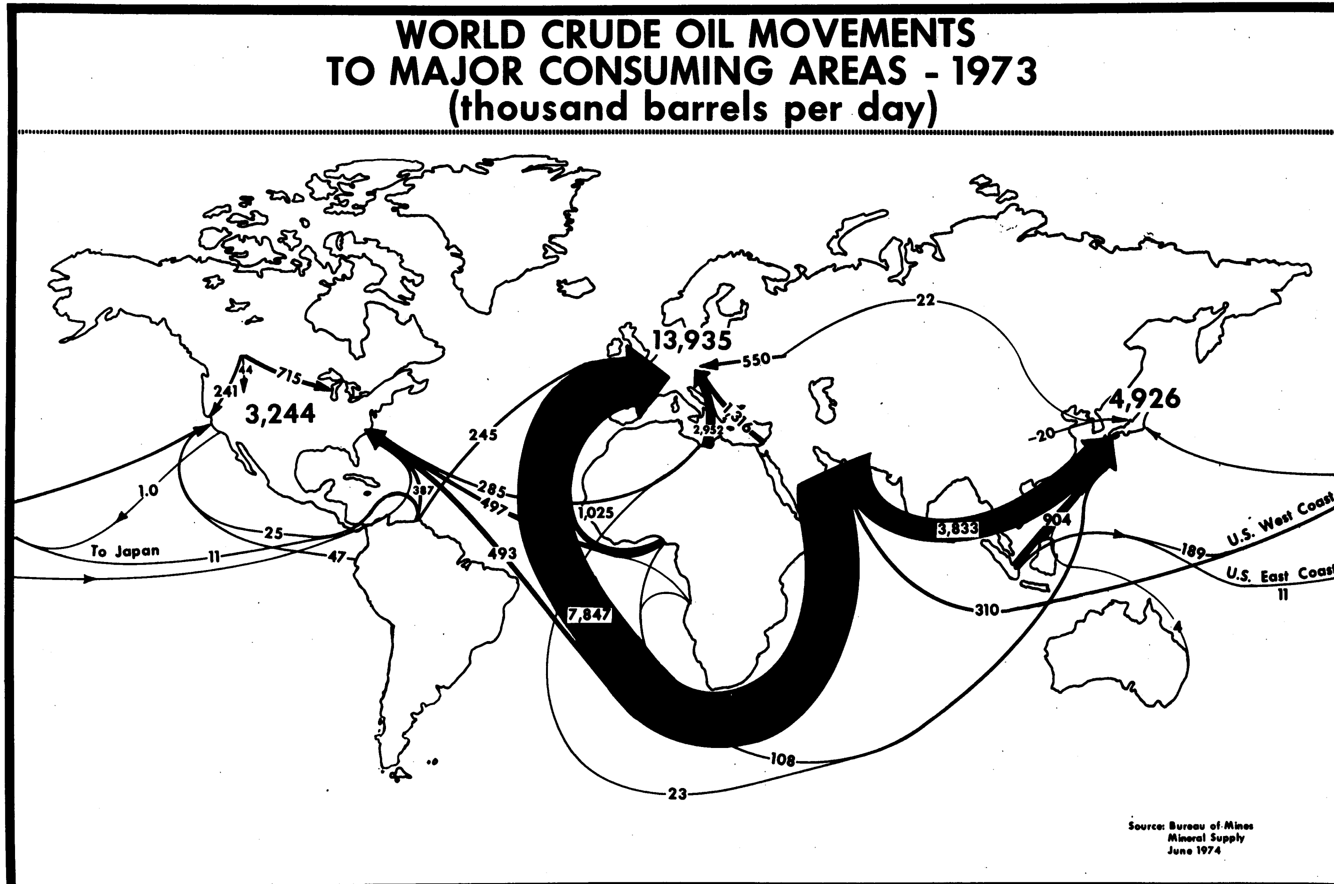


Figure 8.—World share of crude oil production, 1973.

as the major supplier accounting for 1.7 million bpd as compared to 1.6 million bpd in 1972. Crude imports from the neighboring People's Republic of China were inaugurated in 1973. Crude imports from China's Ta-ching field averaged nearly 20,000 bpd in 1973; the volume is expected to increase to 60,000 bpd or better in 1974.

The United States imported 3.2 million bpd in 1973. Canada supplied more than a million bpd, Saudi Arabia, about 462,000 bpd, and Nigeria, 448,000 bpd.

Transportation.—Excluding 37 million deadweight tons in combined carriers, the world tanker fleet at yearend 1973 totaled 220 million deadweight tons, an increase of more than 26% over 1972. About 59 million deadweight tons sail under the Liberian flag, 28 million deadweight tons sail under the United Kingdom flag, about 27 million deadweight tons sail under the Japanese flag, and about 21 million deadweight tons sail under the Norwegian flag. Tankers between 200,000 and 285,000 deadweight tons in size constitute 36% of the total tanker fleet, and tankers of 65 to 125 deadweight tons in size constitute 19% of the total tanker fleet.



(Thousand barrels per day)
Figure 9.—World crude oil movements to major consuming areas, 1973.

Voyages from the Middle East occupied an estimated 75% of the oceangoing fleet. Voyages from the Middle East to Europe and Japan alone occupied about 60% of the total oceangoing fleet.

At yearend, 21 cryogenic ships were in service for the transport of liquid natural gas. Combined capacity totaled 867,000 cubic meters. Liquid petroleum gas vessels numbered 379 with a total carrying capacity of 2.4 million cubic meters.

Refinery Capacity.—Total crude refinery capacity at yearend was estimated at 64.8 million bpd, an increase of 4.95 million bpd over 1972 capacity levels. The Eastern Hemisphere, containing the major refining centers of Europe, the U.S.S.R., and Japan, accounted for nearly 64% of total world refining capacity or 41.4 million bpd. Refining capacity in the Western Hemisphere totaled 23.4 million bpd. Refining capacity in the United States was 14.5 million bpd followed by Canada at 1.8 million bpd and Venezuela at 1.5 million bpd.

Consumption.—World petroleum consumption reached 57.6 million bpd in 1973. Petroleum consumption in the Eastern Hemisphere was estimated at 35.2 million bpd representing an increase of about 12% over the previous year's level. Petroleum consumption in the Western Hemisphere totaled 22.4 million bpd representing an increase of nearly 8% over the 1972 level.

Although total world petroleum consumption increased by less than 12% between 1972 and 1973, several Eastern Hemisphere nations reflected higher percentage increases for the period. These included Spain at 15%, and Japan at 12%.

Algeria.—A slow down in exploration and development programs after the 1971 nationalization as well as the adoption of conservation measures at older fields resulted in a crude production below 1973 anticipated levels. By midyear the Algerian state oil company Société Nationale pour la Recherche, la Production, la Transport, la Transformation, et la Commercialisation des Hydrocarbures (SONATRACH) as well as several minor operators claimed they were over committed in crude exports. Crude exports for the year averaged 945,000 bpd, a decline from the 1972 average of 978,000 bpd. Exploration activities should be intensified as a result of several joint venture agreements signed by SONATRACH with Sun Oil Co. with Compagnie Française des Pétroles, with Hispánica de Petróleos, S.A., with Deutsche Erdölversorgungsgesellschaft mbH and with Société Nationale des Pétroles d'Aquitaine.

Total refining capacity is reported at 115,000 bpd; however, plans for construction of a 175,000 bpd refinery at Skikda were announced.

Austria.—The State company Österreichische Mineral-ölverwaltung, A.G. (ÖMv) reportedly discovered oil and gas deposits near Vienna and at Roseldorf. The discoveries are being studied for commercial potential.

ÖMv produced 82% of total oil output in Austria in 1973 or 40,400 barrels per day. About 175,000 bpd of Austrian and imported crude was processed at the ÖMv refinery at Schwechat. The refinery is to be expanded from present capacity of 210,000 bpd to 280,000 bpd by yearend 1974, satisfying the nation's total product requirements by 1975. A 40,000 bpd products pipeline from the Schwechat refinery to Wels is planned, with completion scheduled for 1975.

Bolivia.—During the year, the state-owned Yacimientos Petrolíferos Fiscales Bolivianos (YPFB) entered into seven operational contracts with foreign companies, mostly American. Each contractor is to finance and undertake exploration of a block of approximately 2.5 million acres. If a block is productive, one-half of the concession reverts to YPFB. The discovery of the Caigua field raised Bolivia's proven reserves to 177 million barrels by yearend 1973. Accelerated exploration activity launched during the year should appreciably augment the nation's petroleum reserves.

In May, YPFB signed service contracts with Universal Oil Products Co., Foster Wheeler Corp., and Lybrand Ross Bros. for expansion of the capacity of the Gualberto Villarrael refinery from 10,000 to 20,000 bpd as well as the construction of a lubricant plant, and expansion of the capacity of the Santa Cruz Refinery from 3,000 to 12,000 bpd.

Expansion plans would raise Bolivian refining capacity to 35,000 bpd. During 1973, a total of 15,160 bpd of crude petroleum was processed in Bolivia's seven refineries.

China, People's Republic of.—Crude production continued to increase sharply, with the bulk of output derived from the north and northeast provinces. China's principal field is Ta-ching, located in the Heilung-

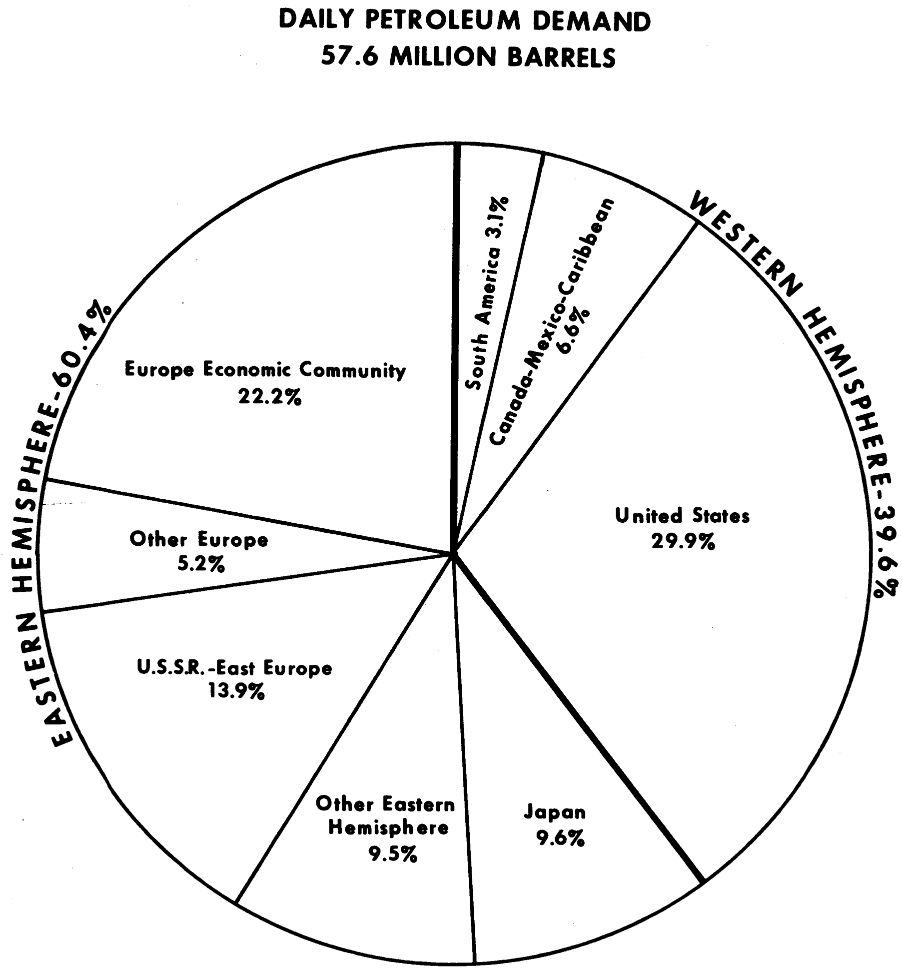


Figure 10.—Daily petroleum demand, 57.6 million barrels.

kiang Province. More than a quarter of the nation's entire output is derived from this field. Pipeline facilities connecting Ta-ching with ports along the Gulf of Liaotung were under consideration and several reports indicated that construction of at least one section had begun during the year. Petroleum storage and shipping facilities were under expansion during 1973 to accommodate increased crude exports. China's petroleum crude and product exports had been directed to North Korea and North Vietnam; however, in early 1973, crude exports to Japan were inaugurated at an average level of 20,000 bpd. By 1974, crude exports to Japan should reach an average of 60,000 bpd or more.

Offshore drilling in the Gulf of Pohai has apparently proved successful. Chinese authorities expressed interest in laying a submarine pipeline from probable fields in the gulf to onshore port facilities.

Refining capacity has historically balanced crude production capacity; however, recent drilling and field development activity have escalated China's crude production beyond refining capacity, and increased crude exports are indicated for the immediate future.

Although primary crude refining reflected only limited growth in 1973, strong activity was reported in the development of the petrochemical industry. Mitsubishi Petrochemical Ltd. (Japan) has received a contract for construction of a 12,000-ton-per-year ethylene plant. Asahi Chemical Industry Co., Ltd. (Japan) will construct a 50,000-ton-per-year acrylonitrile plant utilizing the Standard Oil Co. of Ohio licensed process. Ishikawajima-Harima Heavy Industries Co., Ltd. (Japan) received a contract for construction of a 180,000-ton-per-year low-density polyethylene unit, and a 80,000-ton-per-year polypropylene unit is to be constructed by Mitsui & Co., C. Itoh, and Kosho Corp. (Japan). Other petrochemical plant contracts were awarded to Technip A.T. and Speichim (France), Friedrich Uhde GmbH (West Germany), and Kellogg Continental BV (Netherlands). Completion dates for all plants were scheduled for 1976–77.

Colombia.—Production of crude oil decreased by 6.7% as a result of conservation measures adopted in view of declining reserves. Reserve figures released by the oil ministry were reported at 900 million barrels in 1973. Petroleum exports were to discontinue after 1973 and by 1975–76 Colombia may reverse its role and become a net importer of petroleum.

Drilling activities continued at the Guajira Basin, the Maracaibo Basin, the Llonos Basin, and the Magdalena Basin. Oil was discovered in the Magdalena Basin at a depth of 5,814 feet. The (Tennecol) Tenneco Colombia, Inc. well tested at 675 bpd on a ½-inch choke.

Egypt, Arab Republic of.—Although crude production continued to decline, this trend should be reversed in the near future. Accelerated exploration, field development and secondary recovery operations support the forecast of production levels of 1 million barrels per day by 1980.

The Egyptian General Petroleum Co. (EGPC) issued a series of concession contracts to a number of foreign companies during 1973. Some of the larger concessions included a 18,000-square-kilometer tract in the Nile Valley and Western Desert awarded to Petróleo Brasileiro Internacional, S.A.; a 15,000-square-kilometer offshore tract in the Mediterranean east of Alexandria awarded to Exxon, Egypt, (United States); and a 14,000-square-kilometer tract in the Nile Delta awarded to Continental Oil Co. (United States). Near yearend, the Soviet Union relinquished a 45,000-square-kilometer concession near the Siwa Oasis on the Libyan border. The concession may be reoffered in 1974.

The Gulf of Suez Petroleum Co. (GUPCO) reported a discovery 11 miles northwest of El Morgan field. The new discovery, the "July" field, tested at 5,280 bpd of 32° API crude oil through a ⅜-inch choke. Oil reserves of the 6-square-mile structure were estimated at 300 million barrels. Production at a 30,000 bpd rate is scheduled for early 1974 with expansion to 100,000 or 150,000 bpd by yearend 1974.

A second discovery was reported in 1973. Located offshore near Ras Gharib, the field's initial yields are expected at 50,000 bpd with a potential of 350,000 bpd upon full development.

During 1973, a waterflood pressure maintenance project was under development in the El Morgan field, Egypt's largest producer, with reserves estimated at 1.2 billion barrels. The project operations include the injection of 300,000 to 400,000 bpd of desalinated water from the Gulf of Suez. The cost of the El Morgan waterflood project is more than $30 million; however, a recovery of an estimated additional 1 billion barrels will be realized as a result.

Prior to the October War, Egypt had built up to a 174,400 bpd crude distillation capacity. The Suez Oil Processing Co. began refining operations at the rate of 7,400 bpd at the newly constructed 14,600 bpd capacity Tąntą petroleum refinery in the Nile Delta. The refinery is served by a 112 mile crude pipeline from Suez and a 55 mile products line connecting the refinery to the Musturud storage and distribution area near Cairo. The crude and products pipelines each have a capacity of 40,000 bpd.

During 1973 construction of a 250,000 bpd export refinery was under consideration by the Board of Foreign Investment Authority. The refinery is to be built in the Alexandria free port area at a cost of $400 million. Saudi Arabian and other Persian Gulf crudes will supply the refinery via the proposed Suez-Mediterranean pipeline (Sumed). Refinery products will be marketed in Western Europe.

Contracts for the Sumed line were under negotiation during the year. Bechtel Corp. (United States) signed a preliminary contract for construction of the 210-mile trunkline. At yearend, the Gulf of Suez-Mediterranean Petroleum Pipeline Co. was formed to finance and operate the Sumed pipeline. Construction was to begin in 1974 with the first stage completed in 2 years with an annual throughput capacity of 800,000 bpd through a 42-inch-diameter pipeline. The second stage includes a parallel line to be completed within 6 months of the first stage completion, raising daily throughput capacity to 1.6 million bpd. Additional pump stations and expanded terminal facilities will be required to reach the lines maximum throughput capacity of 2.4 million bpd. During 1973, oil transit agreements were signed with 13 foreign oil companies for a combined 1.67 million bpd of oil shipments via the Sumed pipeline.

Plans to restore the Suez Canal were underway in 1973, with a government allocation of $37.5 million for clearing mines, sunken ships, and bridging. At the time of the closure in 1967, the canal's draught was 38 feet. Deepening the canal to a depth of 70 feet was being considered.

France.—Domestic crude production averaged 0.025 million barrels per day while crude imports averaged 2.7 million barrels per day. Nearly half of total French crude imports are obtained from Saudi Arabia, Iraq, and Kuwait. In a concentrated effort to diversify crude sources, French companies have obtained a variety of concession areas throughout the globe. New concessions obtained in 1973 included areas in North Sea, off the Italian Coast, in Spain, Canada, Peru, and in Colombia. Exploration in France itself is concentrated in the Aquitaine area. Several discoveries were reported in 1973 in the Aquitaine region, in the North Sea, and in Canada.

Crude oil supplies controlled by foreign operations of French companies accounted for ⅔ of crude imports in 1973.

Refinery expansion activities at Fos, Frontigen, Feysin and Donges resulted in nearly a 6% increase in the nation's refining capacity bringing total capacity to 3.2 million bpd in 1973.

Indonesia.—Extensive exploration and development activity continued in 1973, with expenditures estimated at $400 million. Extension and development wells drilled during the year totaled 449. Two hundred exploratory wells were completed, achieving a 1:4 success ratio with the discovery of 50 wells including 28 oil wells, 19 gas wells, and 3 oil and gas wells.

Petroleum production continued to climb, averaging better than 1.3 million bpd in 1973 as compared with 0.9 million bpd in 1970. The bulk of crude output or 0.96 million bpd is recovered by P.T. Caltex Pacific Indonesia (CPI) under a production contract with the state-owned oil company, Pertamina. The production contract calls for a 65% to 35% production ownership in favor of Pertamina.

About three-fourths of Indonesia's crude production is exported, with Japan as the major market receiving 740,000 bpd in 1973. During 1973, eight refineries were in operation with a total capacity of 424,000 bpd. By yearend, construction of a ninth refinery was underway. Constructed by Fluor Engineers & Constructors, Inc., and financed by a $120 million loan from the U.S. Export-Import Bank, the 100,000 bpd Cilacap refinery on the southern coast of Java should be completed by 1976. The refinery will use Persian Gulf crude as feedstock to meet domestic markets for such products as asphalt and lubricants.

Domestic consumption of petroleum products was reported at 170,000 bpd in 1973. The product consumption pattern was 40% kerosine, 25% diesel fuel, 20% gasoline, and 15% other products.

Iran.—In March, Iran assumed ownership and control of all oil installations in the country. The Iranian Oil Participants, Ltd. (IOP) (the Consortium), the largest concessionaire was disbanded but participants were guaranteed supplies of oil for a 20-year period in ratio to their former ownership in IOP. IOP members formed a nonprofit service company, Oil Services Co. of Iran (OSCO), to assist the National Iranian Oil Co. (NIOC) in operations for an initial 5-year period. Production from the former consortium area averaged 5.4 million bpd representing 92% of Iran's crude output in 1973.

Iranian refining operations produced above their designed capacity in 1973. The 40,000 bpd Shiraz refinery was inaugurated in mid-November. Throughput at Shiraz totaled 2.6 million barrels by yearend. Abadan reported an annual throughput of 158.3 million barrels, the Tehran refinery throughput was 34.9 million barrels, the Kermanshah refinery throughput was 6.2 million barrels and a 12.3 million barrel throughput was reported in the topping plant. Expansion of the Tehran refinery to 125,000 bpd was underway as was construction of a second Tehran refinery of 100,000 bpd capacity. Plans were announced for a 100,000 bpd refinery at Isfahan and 130,000 bpd refinery at Neka. The Abadan refinery is to be expanded from 430,000 bpd to 550,000 bpd. Thus, becoming the largest refinery in the world.

Israel.—Israel's second refinery came on stream during the year. The 70,000 bpd refinery at Ashdod brings Israeli refining capacity to well over 200,000 bpd.

Capacity of the Trans-Israeli pipeline (Tipline) was reportedly increased to 900,000 bpd, before the October outbreak of hostilities. The 42-inch line runs 160 miles between the Port of Aqaba on the Red Sea and the port of Ashkelon on the Mediterranean Sea. The eventual capacity of Tipline is projected at 1.2 million bpd.

Italy.—Domestic crude production was limited averaging 19,403 bpd in 1973. Exploration activities continued with several offshore concessions granted in the Sicilian Channel, the Tyrrhenian Sea and in the Adriatic Sea during 1973. Exploratory well completions for the year totaled 63, down from 77 completions reported in 1972.

Italian refining capacity nearing 3.9 million bpd is the largest in Western Europe; however, refineries operated at ⅔ capacity during the year. Major refining operations reported significant losses as a result of prolonged price freezes on petroleum products. British Petroleum Co. sold its 73,000 bpd Volpiano refinery, and more than 3,000 retail outlets along with related transport and distribution equipment to Oil Chemicals and Transport Finance Corp. (Italy). Shell Italiana. S.p.A. sold the 115,000-barrel-per-day-capacity La Spezia refinery, the 100,000 bpd Taranto refinery and the 50,000 bpd Rho refinery along with 4,860 retail outlets and related transportation and distribution equipment to Azienda Generale Italiana Petroli (AGIP).

Price increases for most petroleum products were authorized on September 30. Pump prices were raised by 14 cents to $1.09 and $1.15 per gallon for standard and premium gasoline respectively. Much of the increase was absorbed by an increased manufacturing tax of 10 cents.

Japan.—Domestic production of crude oil has been very limited, ranging from 14,000 to 15,500 bpd in the last decade and peaking in 1970 at 15,500 bpd. Production is derived from fields in the Niigata and Yamagata areas of Honshu Island and from fields near Shiratsukari on Hokkaido Island. A commercial field in the Sea of Japan off Niigata was confirmed and production is scheduled for 1975.

As Japan is dependent upon crude petroleum imports of nearly 5 million bpd, the cutback in receipts of Middle Eastern oil, the source of more than three-fourths of its total crude imports, created a "state of national emergency." An energy saving program went into effect on November 16, 1973, requiring a 10% across-the-board cut in oil and electricity consumption on a government administrative guidance basis. This action was followed by enactment of the Petroleum Supply Adjustment Law and the National Livelihood Stabilization Law both effective on December 22, 1973, which authorized the government to check abnormal commodity price increases and goods shortages arising from oil supply cuts.

Japanese refining capacity was reported at 4.8 million bpd at the close of 1973. Two new refineries were scheduled for operation during the year, the 100,000 bpd Nagoya refinery of Toa Oil Co., Ltd. and the 70,000 bpd Tomakomai refinery of Idemitsu Kosan Co., Ltd. Expansion activities of Nippon Petroleum Refining Co., Ltd. were scheduled for completion near yearend, raising capacity at the Muroran refinery from 10,000 to 110,000 bpd. The Sakai refinery of Kansai Oil Co., Inc., was scheduled for an expansion from 110,000 to 210,000 bpd by the close of 1973. Government authorizations were announced for a 1.4 million bpd additional refining capacity by 1976 and additional authorizations for a total of 1.1 million bpd by 1978.

Several new petroleum companies were formed during the year. On January 31, 1973, Japan Oil Development Co., Ltd., a partnership between Japan Petroleum Development Corp. and nine Japanese oil exploration companies, was formed. The new company purchased 45% of British Petroleum Corp.'s share of Abu Dhabi Marine Areas, Ltd. (ADMA), thus obtaining 30% equity in ADMA which is currently producing a total of 507 bpd from the Umm Shaif and Zakum offshore fields in Abu Dhabi.

The International Oil Co., Ltd. was established March 8, 1973, as a joint venture of 10 private companies. The company arranged for the purchase of nearly 20,000 bpd of crude oil from the Ta-ching field in the People's Republic of China. By 1974 imports of Chinese crude are expected to be 60,000 bpd or more.

Libya.—Crude production continued to decline from the 1970 peak level of 3.31 million bpd. Daily production averaged 2.27 million bpd during the first 10 months of 1973; however, production cutbacks reduced daily output to nearly 1.77 million bpd during November and December, for an overall 1973 daily production average of 2.17 million bpd.

During 1973, Libyan Government activities focused on gaining control of major oil company operations in Libya. In August, Occidental Petroleum Corp. and Oasis Oil Co. signed an agreement accepting 51% government participation in their Libyan operations, at which time the operators were permitted to increase their production rate to 475,000 bpd and 900,000 bpd, respectively. By September the Libyan Government issued a decree unilaterally acquiring 51% participation in the remaining major oil company operations.

The posted price for 40° API gravity Libyan crude was $3.78 per barrel in January. Increments in April, June, July, August, and on October 1 increased the price to $4.60 per barrel, in accordance with OPEC and oil company negotiations that provided price adjustments to compensate for the dollar devaluation. By mid-October prior agreements were abandoned and Libya set posted prices unilaterally. The posted price was nearly doubled at $8.93 per barrel on October 16, increased to $9.06 on November 1, and reached $15.77 by January 1, 1974.

The Libyan Government announced discovery of new oil fields at Ra's al Hilāl in Northeast Libya and near Ghadāmis near the Algerian-Tunisian border. Libyan production has declined steadily since 1970, and extensive exploration and development is necessary if Libya is to maintain her position as the leading African crude producer.

The 60,000 bpd capacity refinery at Az Zawiyah, under contract construction by SNAM Progetti S.A., was near completion by yearend. Doubling of the Az Zawiyah refining capacity was under consideration as well as the construction of a 180,000 bpd refinery at Marsá al Burayqah, a 120,000 bpd refinery at Tobruq, and a jointly owned Libyan-Tunisian refinery at Qabes, Tunisia of 120,000- to 150,000 bpd capacity.

During the year, the Libyan General Organization for Maritime Transport signed agreements for construction of 11 tankers. Nippon Kokan Kabushiki Kaisha (Japan) received a $45.3 million contract for construction of two 118,000-deadweight-ton tankers; the Gotaverken AB shipyard (Sweden) received a $40.8 million contract for three 152,700-deadweight-ton tankers; and two crude tankers of 100,000 to 120,000 deadweight tons each, as well as four 30,000-deadweight-ton product carriers were to be built by Yugoslavia under a barter agreement for 40,000 bpd of Libyan crude for an unreported time period.

Nigeria.—Production continued to climb, increasing from a January 1 production level of 1.91 million bpd to a midyear production level of 2 million bpd, and finally reaching a level of 2.25 million bpd by yearend 1973. Much of the increase was attributable to expanded capacity at the Kolo Creek, Etelbou, and Diebu Creek fields operated by the nation's largest producer, Royal Dutch/Shell and British Petroleum (Shell-BP) in partnership with the Nigerian National Oil Corp. (NNOC). During the year, the Nigerian government represented by the NNOC entered into a participation agreement with Shell-BP acquiring 35% equity in exploration and producing operations. The agreement offers Shell-BP the right to buy back most of the NNOC participation crude. The government engaged in negotiations with other Western operators including Gulf Oil Corp., Mobile Oil Co., and Texaco Overseas (Nigeria) Petroleum Co./Chevron Oil Co. (Nigeria). Although indications were that even higher participation levels were under discussion, no accords were announced by yearend. Government posted prices for 34° API gravity Nigerian crude increased during 1973 from $3.56 per barrel to a high point of $8.40 per barrel and then jumped to $14.69 per barrel on January 1, 1974.

Although the 1973 crude production was obtained essentially from onshore operations, at least eight good test flows were reported during the year from offshore exploratory drilling operations of Japan Petroleum Co. (Nigeria Ltd.), Occidental Petroleum Corp., Deminex and Niger Oil Resources, Texaco Overseas (Nigeria) Petroleum Co., and Chevron Oil Co. (Nigeria). These companies are operating in concession areas awarded in 1972 by an agreement which includes 51% NNOC participation in commercial finds. Promising offshore developments together with expanding onshore operations should in the very near future increase Nigerian crude output to the point of surpassing Libya as the leading African crude producer.

The Nigerian government announced plans for construction of a second refinery. Tentative plans call for construction of a 30,000 bpd capacity refinery at Warri. Proposed completion date is 1976.

Norway.—In spite of a 65-day shutdown because of bad weather conditions in the North Sea during 1973, the Phillips Petroleum Co. group reported production of more than 11 million barrels of crude from four wells in the Ekofisk field. A 1-million-barrel-capacity concrete storage tank was towed to the production site in June 1973 and set in place in 230 feet of water. The tank should be serviceable by mid-1974 permitting crude storage when tanker loadings are prohibited by bad weather. The 34-inch-diameter crude oil pipeline between the Ekofisk field and Teesside, England, a distance of 220 miles was near completion by yearend. Throughput capacity is 1 million barrels per day. Terminal facilities at Teesside are scheduled for completion in 1975.

A 80,000 bpd refinery was under construction at Mongstad, near Bergen under contract to Foster Wheeler Corp. (United States). Completion is scheduled for early 1975.

An agreement reached during 1973 between the government and the Ekofisk producers reserves sufficient amounts of natural gas liquids, landed in Norway free of freight charges, to sustain operations of a 250,000-ton-per-year ethylene plant.

Saudi Arabia.—Saudi Arabia remained the third largest world producer of crude oil. Output for the year averaged 7.9 million bpd including a peak level of 8.4 million bpd in July and a low of 6.1 million bpd in November following the Arab production cutback policy.

The Arabian American Oil Co. (Aramco) reported discovery of a major new offshore field at Maharah. By midyear Aramco's offshore Zuluf field went into production at 80,000 bpd and the onshore Harmaliyah field went into production at 100,000 bpd with output anticipated at 150,000 in 1974. Transportation and loading facilities were under construction. A fourth sea loading berth as well as additional storage capacity of 5.5 million barrels came into service at Ras Tanura. A total of 18 tankers can be loaded simultaneously from the port's two T-head piers and 4 sea berths. Plans were announced for construction of a 46-inch and 48-inch pipeline from Abqaiq to Ju'anura (15 miles northwest of Ras Tanura) with accompanying storage facilities and with offshore loading capacity of 140,000 barrels per hour into tankers as large as 500,000 deadweight tons.

The Saudi Arabian Government acquired 25% participation in Aramco reducing equity holdings of Standard Oil Co. of California, Texaco Inc., and Exxon Corp., to 22.5% with Mobil Oil Corp. holding 7.5%.

United Arab Emirates.—Abu Dhabi, averaging 1.3 million bpd and Dubai averaging 0.2 million bpd were the only producers of commercial crude in the United Arab Emirates. Sharjah will, however, join their ranks when the Mubarek field enters production, possibly by mid-1974. By agreement, Sharjah will share royalties with Iran on production from the Mubarek field. Sharjah's Mubarek crude will be sold to Japan Lines, Ltd.

Several offshore concession agreements were under negotiation during the year. These included concessions totaling 1,650 square miles off the Gulf of Oman in waters of Fujairah and Sharjah as well as 232 square miles of offshore Ajman on the Persian Gulf. Reserve Oil & Gas Co. and United Refining Co. (United States) were included in the negotiations.

Construction plans were affirmed for a 15,000 bpd refinery at Umm al Nar (Abu Dhabi) to be supplied via a 20,000 bpd capacity line running from Habshan (Abu Dhabi) a distance of 76 miles.

Financing for Dubai's massive dry dock project was arranged and construction of facilities for servicing two 500,000 deadweight ton tankers and a million deadweight ton tanker will soon be inaugurated.

U.S.S.R.—Crude production neared an average of 8.5 million bpd in 1973, an increase of 6.9% over the previous year's production level. Tataria, Tyumen, and Bashkiriya were the nation's major producing areas accounting for nearly one-third of total crude output in 1973. Soviet sources report five new discoveries in Tataria during 1973. Two fields in the Bashkiriya area the Teplykovskoye and Burayëvskaya fields entered production during the year. The Samotlor field in Tyumen produced at an average of 340,000 bpd with production averages forecasted at more than 1 million bpd in 1974, as a result of flooding projects. The oil zone is located 8,200 feet below Lake Samotlor.

Negotiations were conducted on the possible Japanese and U.S. participation in development of the Tyumen field. Preliminary discussions indicated a possible export of 800,000 bpd via a pipeline to a Pacific terminal. Subsequent discussions reduced proposed export levels to 500,000 bpd. No agreement was reached by yearend.

Crude and product exports from the U.S.S.R. averaged nearly 2.4 million bpd in 1973. East European nations received nearly 1.4 million barrels per day. To facilitate exports, a 48-inch pipeline was under construction to move crude from the western Siberian fields across the Ural Mountains to Ufa and Kuyibyshev then to Tikhoretsk and the Black Sea port of Novorossiysk.

United Kingdom.—Forty-four exploration wells were drilled in British North Sea waters in 1973, 35 in the North, 8 in the South, and 1 in the Celtic Sea.

In January, the Occidental Group, which holds a production license in the North Sea for 494 square miles, drilled the Piper discovery well in Block 15/17-1A in 475 feet of water. The discovery well was tested at a combined rate of 8,848 bpd of low-sulfur oil averaging 37° API from two zones. In March, a second Piper field well, drilled 2 miles north of the discovery well, tested at a combined rate of 32,129 bpd from the two zones. Four more appraisal wells were drilled confirming the Piper field as a major North Sea oil field. Using a recovery factor of 40%, production potential of the field is estimated at 650 million barrels. Initial production is scheduled for 1975 at 100,000 bpd, building up to 200,000 bpd by 1976. Construction of a 130 mile, 30-inch diameter submarine pipeline connecting the field to an Orkney Island terminal is scheduled for completion in mid-1974.

In early 1973, Phillips Petroleum Co. reported a discovery well in Block 16/29 testing at 3,500 bpd of 36° API crude. The Maureen field lies in 300 feet of water.

By midyear the Shell/Esso group reported a discovery well in Block 211/23, and an appraisal well in Block 211/29 increased recoverable reserve estimates for the Brent field to 1,500 million barrels.

The Total group reported a discovery in Block 3/15 testing at 3,000 bpd of 42° API crude through a ½-inch choke.

Several confirmations and extensions were made on 1972 discoveries. These included the Mobil group's Beryl field in Block 9/13, the Thistle field in Block 211/18, and Shell/Esso's Brent field in 211/29.

Production from Shell/Esso's Auk field discovered in 1970 in Block 30/16 was delayed by 1 year, and production is now anticipated by 1975. Production from the Brent field is anticipated by early 1976, Beryl field is scheduled for production in late 1975, and the Thistle field should be in production by 1976.

The construction of a new refinery and several refinery expansions were reported in 1973. American Oil Co.'s 80,000 bpd Milford Haven refinery was in operation by October. Mobil Oil Co. Ltd.'s Coryton refinery and Texaco Ltd.'s Pennbrook refinery were both expanded from 140,000 bpd to 180,000 bpd.

Zaire.—The nation should enter the ranks of petroleum producers by 1975 when two offshore fields are brought into production by Gulf Oil Zaire which holds 50% equity in a group comprised of Japan Petroleum Zaire with 32.8% equity, and the Belgian firm Ste. du Littoral Zairois Soliza with 17.2% equity. Initial production is anticipated at 25,000 barrels per day.

The government in partnership with Italy's Ente Nazionale Idrocarburi operated a 16,000 bpd capacity refinery at Moanda. Crude petroleum imports from Iran, Saudi Arabia, and Nigeria totaled 14,325 bpd. Petroleum product imports were reported at 2,750 bpd. In December, the government nationalized the marketing facilities of Mobil Oil Co., Texaco, Fina, and Royal Dutch/Shell, placing marketing operations under control of the Ministry of Energy.

TECHNOLOGY

Delta Exploration Co., Inc. was using a patent-pending combination barge and ship to cover both deep and shallow water exploration. The separate 76-foot recording barge is carried on the stern of the 165-foot mother ship which operates well out to sea. Within 10 miles of shore, the barge can be released for operations in water as shallow as 4 feet. Seismic units on the vessel contain Gardner-Denver 2,000-psi compressors powering two 1,000-cubic-inch and two 300-cubic-inch Bolt air guns. Delta's boat and barge system was operating in South America in 1973.[6]

A direct-current electric-power swivel was field tested at Gulf of Mexico locations offshore from Louisiana. Industry's first electrically powered drilling swivel was subjected to a variety of field operating conditions on four recently completed holes. The Bowen Tools, Inc. and Brown Oil Tools, Inc., swivel was installed while working on an Atlantic Richfield Co. platform in Eugene Island Block 175 field.

Specific advantages of the 750-horsepower electric swivel on these wells included the following:

1. Safety, only the driller and one floorman are necessary to make a connection. No spinning chain is needed (the swivel is rotated to make up tool joints) and tongs are not required if the special backup powerslips designed for use with the swivel are installed.
2. Fewer downhole surveys are required to orient the large nozzle in the bit when jetting to establish a directional hole, since reference points to the large nozzle are made on the torque elevators and are always available above the rotary.
3. Weight of the power swivel plus the fact it runs on a guide track allows drilling operations to continue even in high winds, a common occurrence in many offshore areas.
4. Since all swivel operations can be precisely controlled, downhole tools are easier to set.[7]

Contractors and operators are developing and successfully testing new rigs and associated equipment that will allow drilling during the severest weather. Advances in downhole tools are helping to quickly and safely evaluate holes drilled from floating vessels. Recent developments include the following:

1. A procedure for well bore re-entry and drilling in water depths of more than 1,000 feet;
2. A revolutionary deep water jackup;
3. An ice-breaking drillship;
4. Two proposed platforms with ice-cutting equipment; and
5. A drillstem test tool for floating rigs.[8]

An oil recovery system that reportedly can recover oil spills offshore in high seas with 8-foot waves has been developed and tested by Ocean Systems, Inc. The system contains a double flotation arrangement with two weirs arranged in such a way that oil thickens in front of the primary weir, then further thickens in front of the second weir, where it enters a collection tube leading to a floating pump and collector.[9]

A feasibility design has been completed for an Arctic marine, crude oil transportation system consisting of a depth-controlled, submerged barge towed by a powerful, surface icebreaking tug. Continental Oil Co., with assistance from Arctic, Inc., investigated this proposal as a means for transporting crude from Alaska's North Slopes to eastern U.S. markets.

Because the cargo is carried below the ice-water surface, the system can achieve speeds through an ice field greater than a conventional ice breaker of equal power. This feature, combined with low total system costs, can give an economical edge over alternate marine systems. The system is reportedly feasible, and with a suitable development program, an operational system could be realized with existing technology.[10]

The increasing use of reinforced concrete for offshore construction of nearly any type from floating nuclear powerplants to permanent drilling and production platforms is evident. North Sea operators, encouraged by recent studies that indicate stable seafloor conditions in at least some areas of interest, are seriously considering concrete platforms for future installations. Recent tests on concrete installed in the ocean 67 years ago, indicate that compres-

[6] World Oil. Piggyback Barge. V. 176, No. 6, May 1973, p. 13.

[7] World Oil. Drilling Experience with the Electric Power Swivel. V. 176, No. 7, June 1973, p. 43.

[8] World Oil. Unique Equipment Designs Should Cut Drilling Costs. V. 177, No. 1, July 1973, p. 94.

[9] World Oil. High Sea Oil Recovery. V. 177, No. 1, July 1973, p. 101.

[10] World Oil. New Way to Move Arctic Oil. V. 177, No. 1, July 1973, p. 100.

sive strength, in three cases, had actually increased since a similar test was made 40 years ago. Other core tests made on concrete harbors built in 1942 in Britain revealed superior concrete strength retention and no deterioration of reinforcing metal.[11]

The first concrete production platform has reportedly been ordered by Mobil Producing North Sea, Ltd. for use in the Mobil group's Beryl field located in the United Kingdom North Sea in 380-foot water. The $50 million Condeep design structure is to be built by a Norwegian consortium in Stavanger, Norway for 1975 delivery.[12]

Onsite seismic analysis is being provided by a new Unicomp Inc. system. Integrated with a minicomputer, the Spectar 2000 unit can simultaneously process and display data from 256 sensing stations. The method is claimed to be 10 to 100 times faster than software techniques, and it indicates to crews where further exploration is warranted. The unit also stores data for processing later on a laboratory computer. Digital Resources Corp. will use the system for a massive exploration program in Bolivia.[13]

A new way to make holes, ranging in size from telephone conduit to subway tunnels was demonstrated recently by Los Alamos, N. Mex., Scientific Laboratory and the National Science Foundation. The technique, Subterrene, is an offspring of the atomic energy program and occurred to program managers while components for a new type of nuclear reactor were being tested under high-temperature conditions. Subterrene works by melting rock or soil with an electrically heated element. Few rocks have a melting point high enough to withstand the probe's 2,200° F temperature.

Rock quarry demonstrations at Fort Belvoir, Va., featured two small probes, one less than 2 inches, the other about 2½ inches in diameter. But, larger instruments are feasible. Subterrene's first application was an Indian ruin in the Randelier National Monument near Los Alamos. Archaeologists wanted drainage built into a ruined ceremonial chamber to halt further deterioration, but were afraid vibrations from conventional drilling would damage the site. A 3-inch hole, 8 feet deep, was melted for water drainage and it had its own high-density glass casing created by the melted rock.[14]

The increasing number of directional wells being drilled has accelerated development of cost saving directional drilling equipment. The recent introduction of two new directional tools, available from Dyna-Drill Co., a division of Smith International, Inc., has added measurably to the state-of-the-art of directional drilling.

One tool, a hydraulically actuated bent sub, has proven its ability to cut costs primarily through reducing round trips. With a simple adjustment (made downhole) to the tool, an operator may switch from straight to directional drilling.

The main advantage of the Teleorienter is its ability to transmit orientation data to the surface any time it is required without the need of wireline services. Both tools have been operational for about 1 year and case histories have indicated each to be a useful directional drilling tool.[15]

The immediate need for fuel desulfurization is being stimulated by tight restrictions on sulfur oxide emissions and by expanding fuel oil markets that are becoming more dependent on high-sulfur foreign crude. Hydrocarbon fuels from tar sands, oil shale, and coal, which are expected to ease our impending energy crisis, are all high in sulfur. Moreover, alternative, nonfuel markets for high-sulfur products such as asphalt are rapidly becoming saturated. As a consequence, hydrodesulfurization processes are playing increasingly important roles in refiners' efforts to produce low-sulfur fuels. Amoco Oil Co. has developed a process for the low-pressure hydrodesulfurization of heavy distillates such as vacuum gas oils or decanted oils. The process will operate at total pressures well below those conventionally used and can achieve 90% desulfurization on most feeds. For virgin feedstocks, catalyst life will approach that obtained at high pressure while even with cracked stocks such as decanted oil the catalyst will give satisfactory life. Investments can be reduced by 30% to 40% over conventional designs, leading to substantial savings in the overall cost of preparing low-sulfur blending stocks. Hydrogen consumption is also substantially less for the low-pressure design, leading to

[11] World Oil. Concrete Structures Emphasized. V. 177, No. 1, July 1973, p. 99.
[12] World Oil. V. 177, No. 4, September 1973, p. 13.
[13] World Oil. On-Site Seismic Analysis. V. 177, No. 2, August 1973, p. 16.
[14] World Oil. V. 178, No. 2, February 1974, p. 13.
[15] World Oil. Two New Directional Tools are Proven Cost Cutters. V. 178, No. 2, February 1974, p. 43.

lower heats of reaction and simplified reactor design.[16]

The Dilchill Dewaxing Process was developed for ketone dewaxing based on direct heat exchange with cold solvent in a highly sheared environment. This process produces highly discrete and stable wax crystal agglomerates, thereby facilitating the separation of wax from oil at high yields and high throughput. The process significantly reduces the need for costly and cumbersome scraped surface exchangers, improves operation of those that are needed, and reduces overall filter area requirements. Furthermore, this process allows integration between dewaxing and refined wax manufacture, eliminating the need for a costly, separate recrystallization plant. In combination with either lube or wax hydrofining, this represents a total process package for dewaxing, wax manufacture and lube and wax finishing.[17]

The responsible disposal of used lubricating oils is a serious problem. Recent Impetus on waste recovery leads to renewed interest in re-refining—to convert this waste oil into useful products. Yet conventional rerefining can also lead to waste byproducts: Spent acid, spent caustic, spent clay, sulfur dioxide, and others. Laboratory data show a good quality lube base stock may be prepared from automotive crankcase drainings. The process includes distillation of the used oil to obtain a lube distillate which is then hydrofined.[18]

The Gasynthan Process, developed by Badische Anilin und Soda Fabrik/Lurgi, offers a proven route to synthetic natural gas (SNG). An SNG plant incorporates naphtha desulfurization, naphtha catalytic reforming with steam to methane-rich gas, methanation of rich gas hydrogen and CO_2, and removal of CO_2 to meet the desired gas quality.

A number of process routes are possible by combining single or two-stage gasification with one or more downstream methanation steps. However, one route best suits any particular application depending on feedstock type and availability, plant location, integration with other plant units, and other project criteria. The four basic possibilities are as follows: (1) Single-stage gasification (Standard Gasynthan) followed by one or two methanation steps, (2) two-stage gasification (Advanced Gasynthan) followed by one methanation step, (3) single-stage gasification with one methanation step and recycle of low CO_2-product gas (this route has a lower net stream requirement (about 0.7 lb/lb naphtha) and the highest efficiency), and (4) single-stage gasification at low temperature (low temperature Gasynthan) and low-steam-to-naphtha ratio followed by single-stage methanation.[19]

The Bureau of Mines continued to focus on improved technology for discovery and production of petroleum. Research was directed toward development of methods of stimulating production from oil and gas reservoirs. Laboratory studies were made to improve tertiary oil recovery by injection of fluids supplemented by micellar-polymer solutions to literally scrub the oil from the reservoir rock. Plans were initiated for a field demonstration of micellar-polymer flooding.

Field research continued to determine the potential application of gamma-ray anomalies at the surface and particularly those over known hydrocarbon deposits in petroleum-producing areas.

The Bureau of Mines SolFrac process was field tested in Labette County, Kans., utilizing a combination of chemical explosive fracturing and solvent injection for heavy-oil recovery. The process recovered 40 barrels of viscous immobile oil during the first 5-month test period.

Laboratory equipment was assembled for testing oil recovery from tar sands by the reverse combustion process. Tests were made with tar sands from deposits in Utah to develop data needed for a field demonstration. In a reverse combustion test from a vertical sand pack of tar sand from the P.R. (Pear) Spring deposit, an oil recovery of 47.4 volume-percent was obtained along with a significant increase in gravity of the oil from about 8° to over 22° API.

Research on petroleum composition included a project on the identification of oil spills. A data bank showing unique properties of crude oils that are shipped by

[16] McBride, Warren L., and James F. Mosby. Low Pressure Heavy Distillate Ultrarefining. Proc. Annual Meeting, National Petroleum Refiners Association, Apr. 1–3, 1973, Whiting, Indiana. National Petroleum Refiners Association, 11 pp.

[17] Hydrocarbon Processing. New Route to Better Wax. V. 52, No. 9, September 1973, p. 141–146.

[18] Hydrocarbon Processing. To Hydrotreat Waste Lube Oil. V. 52, No. 9, September 1973, p. 134.

[19] Hydrocarbon Processing. Gasynthan Process for SNG. V. 52, No. 1, January 1973, pp. 93–98.

tankers is being developed to provide information for identifying the sources of oil spills.

In research on re-refining waste lubricating oils, a solvent-extraction and distillation procedure was developed that removes contaminants from waste lubricating oils without adversely affecting the hydrocarbon composition of the oil.

The systematic scheme developed by the Bureau of Mines to separate heavy crude oil distillates into compound-type concentrates was applied to five foreign crude oils. Research continued on spectral characterization of these concentrates to provide information needed for efficient processing of these low-grade distillates into quality fuels.

Table 2.—Supply, demand, and stocks of all oils in the United States

(Thousand barrels)

Item	1969	1970	1971	1972	1973 p
Domestic production:					
Crude oil	3,203,996	3,350,666	3,296,612	3,293,399	3,206,012
Lease condensate	167,755	166,784	157,302	161,969	154,891
Natural gas plant liquids	580,241	605,916	617,815	638,216	634,423
Imports:					
Crude oil [1]	514,114	483,293	613,417	811,135	1,183,996
Unfinished oils [1]	38,766	39,261	45,193	45,705	50,161
Plant condensate	--	2,258	13,321	31,428	[2] 37,475
Refined products	602,671	723,250	760,949	847,046	991,891
Other hydrocarbons and hydrogen refinery input	4,213	6,238	6,074	10,118	10,716
Total new supply	5,111,756	5,377,666	5,510,683	5,839,016	6,269,565
Unaccounted for crude oil [3]	−2,561	−7,721	+14,823	+10,201	+918
Processing gain	122,412	131,052	139,433	142,161	165,488
Total supply	5,231,607	5,500,997	5,664,939	5,991,378	6,435,971
Change in stocks of all oil	−17,449	+37,738	+26,086	−84,968	+49,328
Total disposition of primary supply	5,249,056	5,463,259	5,638,853	6,076,346	6,386,643
Exports: [4]					
Crude oil	1,436	4,991	503	187	697
Refined products	83,449	89,467	81,342	81,202	83,515
Crude losses	4,241	4,328	4,448	4,641	4,897
Domestic demand for products:					
Gasoline:					
Motor gasoline	2,016,995	2,111,349	2,195,267	2,333,778	2,435,501
Aviation gasoline	25,551	19,903	17,892	16,925	16,531
Total gasoline	2,042,546	2,131,252	2,213,159	2,350,703	2,452,032
Jet fuel:					
Naphtha type	108,518	90,927	94,732	88,495	79,220
Kerosine type	253,213	262,051	273,991	293,995	304,135
Total jet fuel	361,731	352,978	368,723	382,490	383,355
Ethane (including ethylene)	72,216	83,757	87,744	106,201	119,443
Liquefied gases	373,410	363,059	369,008	413,649	409,116
Kerosine	100,369	95,974	90,917	85,852	78,915
Distillate fuel oil	900,262	927,211	971,316	1,066,110	1,124,308
Residual fuel oil	721,924	804,288	838,045	925,647	1,019,934
Petrochemical feedstocks [5]	94,648	101,183	110,525	123,697	130,967
Special naphthas	29,598	31,390	29,762	31,866	32,230
Lubricants	48,782	49,693	49,321	52,813	59,037
Wax	4,588	4,607	5,248	5,409	6,941
Coke	80,830	77,215	79,897	88,276	95,126
Asphalt	143,290	153,477	158,526	163,788	182,602
Road oil	8,756	9,641	8,487	7,538	7,832
Still gas for fuel	160,363	163,905	156,967	170,993	176,758
Miscellaneous products	16,617	14,843	14,915	15,284	18,938
Total domestic demand	5,159,930	5,364,473	5,552,560	5,990,316	6,297,534
Stocks of all oils:					
Crude oil and lease condensate	265,227	276,367	259,648	246,395	242,478
Unfinished oils	97,819	98,989	100,574	94,761	99,154
Natural gasoline and plant condensate [6]	5,704	7,046	6,176	6,075	7,835
Refined products	611,373	635,459	677,549	611,748	658,840
Total	980,123	1,017,861	1,043,947	958,979	1,008,307

p Preliminary (except for crude oil and lease condensate production).
[1] Reported to the Bureau of Mines. Imports of crude oil include some Athabasca hydrocarbons.
[2] Excludes imports for substitute natural gas (SNG) plant feedstock use.
[3] Represents the difference between supply and indicated demand for crude petroleum.
[4] U. S. Department of Commerce data.
[5] Produced at petroleum refineries. Demands for ethane and liquefied gases used for petroleum feedstocks are excluded. Demand data for these products for petrochemical feedstocks use are included under the items "Ethane" and "Liquefied gases."
[6] Includes isopentane.

Table 3.—Supply, demand and stocks of all oils in the United States, by month

(Thousand barrels)

1972	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
New supply:													
Domestic production:													
Crude oil	268,442	257,325	279,358	272,039	284,217	272,573	281,082	280,685	272,575	280,491	269,079	275,533	3,293,399
Lease condensate	14,101	13,424	13,953	13,350	13,826	13,073	13,303	13,273	12,674	13,438	13,714	13,840	161,969
Natrual gas plant liquids	52,840	50,649	54,814	53,073	53,842	52,028	53,668	53,896	52,533	54,825	52,710	53,338	638,216
Imports:													
Crude petroleum [1]	63,419	60,344	64,066	60,129	66,958	62,544	67,635	65,463	70,909	78,003	68,978	82,687	811,135
Unfinished oils [1]	5,520	4,189	3,234	3,542	2,495	3,011	3,339	3,600	3,956	4,214	3,846	4,759	45,705
Plant condensate [2]	1,748	1,758	2,196	1,782	2,701	2,414	2,770	3,309	3,039	2,963	3,365	3,383	31,428
Refined products	77,097	74,217	79,199	63,616	63,244	66,035	62,550	65,748	63,269	73,636	72,378	86,057	847,046
Other hydrocarbons and hydrogen refinery input	578	614	883	808	732	808	862	1,012	757	1,006	1,167	891	10,118
Total new supply	483,745	462,520	497,703	468,339	488,015	472,486	485,209	486,986	479,712	508,576	485,237	520,488	5,839,016
Crude petroleum unaccounted for [3]	−831	+853	+963	−1,387	+4,381	−315	+1,645	+2,852	+793	−214	+2,130	−669	+10,201
Processing gain	11,501	9,828	11,808	10,977	10,807	10,112	11,199	13,826	12,285	13,817	12,043	13,958	142,161
Total supply	494,415	473,201	510,474	477,929	503,203	482,283	498,053	503,664	492,790	522,179	499,410	533,777	5,991,378
Change in stocks, all oils [4]	−30,013	−49,831	−21,803	+4,334	+37,799	+7,199	+31,766	+1,909	+20,881	+4,434	−36,703	−54,940	−84,968
Total disposition of primary supply	524,428	523,032	532,277	473,595	465,404	475,084	466,287	501,755	471,909	517,745	536,113	588,717	6,076,346
Exports: [5]													
Crude oil	--	--	--	187	--	--	--	--	--	--	--	--	187
Refined products	5,257	4,706	8,927	7,181	6,173	6,257	6,441	7,346	6,840	7,231	7,422	7,421	81,202
Crude losses	383	359	382	366	386	385	399	399	393	398	386	405	4,641
Domestic demand for products:													
Gasoline:													
Motor gasoline	172,003	165,591	198,768	188,502	199,795	204,665	206,849	215,084	193,582	196,848	194,362	197,729	2,333,778
Aviation gasoline	1,242	1,298	1,723	1,457	1,407	1,505	1,526	1,499	1,351	1,677	1,135	1,105	16,925
Total gasoline	173,245	166,889	200,491	189,959	201,202	206,170	208,375	216,583	194,933	198,525	195,497	198,834	2,350,703
Jet fuel:													
Naphtha type	6,765	7,507	6,581	7,944	8,229	7,998	7,159	6,835	7,079	7,934	7,846	6,618	88,495
Kerosine type	24,871	25,574	24,664	21,629	22,755	26,901	23,828	22,497	23,958	28,375	23,643	25,300	293,995
Total jet fuel	31,636	33,081	31,245	29,573	30,984	34,899	30,987	29,332	31,037	36,309	31,489	31,918	382,490
Ethane (including ethylene)	8,387	8,200	9,019	8,111	8,473	8,377	9,196	9,246	9,060	9,787	8,889	9,456	106,201
Liquefied gases:													
LRG [6] for fuel use	7,501	7,575	6,680	5,935	6,197	6,968	6,548	6,796	6,674	6,979	7,554	8,612	84,019
LRG [6] for chemical use	2,988	2,831	3,013	2,994	3,356	3,227	3,284	3,173	2,867	2,939	2,796	3,275	36,743
LPG [7] for fuel and chemical use	35,251	32,199	25,199	18,393	12,847	14,873	15,709	19,339	18,721	27,578	33,796	38,982	292,887
Total liquefied gases	45,740	42,605	34,892	27,322	22,400	25,068	25,541	29,308	28,262	37,496	44,146	50,869	413,649

See footnotes at end of table.

Table 3.—Supply, demand and stocks of all oils in the United States, by month—Continued

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Domestic demand for products—Continued													
Kerosine	11,817	10,703	8,769	5,266	4,432	3,475	2,861	5,295	5,943	7,365	8,554	11,372	85,852
Distillate fuel oil	115,413	120,757	107,941	83,332	69,764	65,817	54,726	63,980	66,160	85,536	101,500	131,184	1,066,110
Residual fuel oil	87,275	91,953	83,151	73,311	65,439	65,873	65,327	69,970	67,161	73,210	85,283	97,694	925,647
Petrochemical feedstocks: [8]													
Still gas	1,230	1,055	1,033	935	1,095	1,147	1,378	1,444	1,144	1,500	1,360	1,357	14,678
Naphtha–400°	5,148	4,562	4,393	5,012	4,798	4,874	4,803	4,894	4,419	4,782	4,777	5,613	58,075
Other	3,618	3,803	4,223	4,154	4,615	3,360	4,095	4,462	4,943	5,365	3,806	4,500	50,944
Total petrochemical feedstocks	9,996	9,420	9,649	10,101	10,508	9,381	10,276	10,800	10,506	11,647	9,943	11,470	123,697
Special naphthas	2,501	2,457	3,194	2,401	2,688	2,811	2,426	2,945	2,632	2,917	2,253	2,641	31,866
Lubricants	3,735	4,142	4,594	4,551	4,534	4,315	4,850	4,747	4,303	4,605	4,571	3,866	52,813
Wax	399	422	400	426	463	484	424	504	476	468	490	453	5,409
Coke	7,784	7,211	6,922	6,454	6,443	6,113	6,790	8,411	7,548	8,088	8,294	8,218	88,276
Asphalt	5,691	6,096	7,547	10,110	15,681	19,222	20,014	24,243	19,727	17,557	11,260	6,640	163,788
Road oil	167	86	174	335	848	1,047	1,347	1,334	1,039	771	287	103	7,538
Still gas	13,814	12,700	13,514	13,375	13,977	14,381	15,171	15,589	14,642	14,573	14,308	14,949	170,993
Miscellaneous products	1,188	1,245	1,466	1,234	1,009	1,009	1,136	1,723	1,247	1,262	1,541	1,224	15,284
Total domestic demand	518,788	517,967	522,968	465,861	458,845	468,442	459,447	494,010	464,676	510,116	528,305	580,891	5,990,316
Stocks all oils:													
Crude oil and lease condensate	251,012	252,945	258,902	266,636	279,490	271,381	265,843	257,976	250,802	253,748	251,306	246,395	246,395
Unfinished oils	102,763	99,110	103,137	106,890	109,535	114,054	109,574	104,871	106,043	103,482	101,221	94,761	94,761
Natural gasoline and plant condensate [9]	6,395	6,543	6,633	6,737	6,766	6,392	6,416	7,019	7,023	6,740	6,295	6,075	6,075
Refined products	653,764	605,505	573,628	566,371	588,642	599,805	641,565	655,441	682,320	686,652	655,097	611,748	611,748
Total	1,013,934	964,103	942,300	946,634	984,433	991,632	1,023,398	1,025,307	1,046,188	1,050,622	1,013,919	958,979	958,979
1973 p													
New supply:													
Domestic production:													
Crude oil	270,863	250,559	273,800	265,736	274,438	263,686	272,847	271,381	259,640	273,071	262,223	267,768	3,206,012
Lease condensate	13,591	12,507	13,630	13,021	12,696	12,732	12,884	12,844	12,319	12,869	12,606	13,192	154,891
Natural gas plant liquids	52,081	48,857	53,769	52,488	53,917	51,801	53,846	54,183	52,233	54,444	53,219	53,585	634,423
Imports:													
Crude petroleum [1]	84,693	80,433	98,021	91,459	99,654	96,613	108,530	111,368	104,117	115,905	103,570	89,633	1,183,996
Unfinished oils [1]	3,278	2,479	4,181	4,786	4,002	4,642	4,475	4,515	4,601	3,588	4,953	4,661	50,161
Plant condensate	3,367	3,411	3,454	3,265	3,153	2,622	3,281	3,166	2,935	2,665	3,188	2,968	[2] 37,475
Refined products	88,796	92,138	98,167	68,141	73,523	72,504	75,047	82,626	79,574	80,115	94,213	87,047	991,891
Other hydrocarbons and hydrogen refinery input	856	942	1,000	700	989	846	978	948	905	895	749	908	10,716
Total new supply	517,525	491,326	546,022	499,596	522,372	505,446	531,888	541,031	516,324	543,552	534,721	519,762	6,269,565
Crude petroleum unaccounted for [3]	+612	−3,637	+2,352	+1,466	+3,924	+5,041	−2,979	+2,046	−5,121	−110	−2,337	−339	+918

Processing gain	14,188	11,476	12,452	11,205	16,536	14,817	14,596	14,579	13,752	15,596	12,907	13,384	165,488
Total supply	532,325	499,165	560,826	512,267	542,832	525,304	543,505	557,656	524,955	559,038	545,291	532,807	6,435,971
Change in stocks, all oils [4]	−53,268	−38,832	+20,507	+25,914	+20,399	+24,312	+28,287	+10,657	+18,686	+21,799	−14,202	−14,931	+49,328
Total disposition of primary supply	585,593	537,997	540,319	486,353	522,433	500,992	515,218	546,999	506,269	537,239	559,493	547,738	6,386,643
Exports: [5]													
Crude oil	--	--	--	--	128	--	232	--	160	--	--	177	697
Refined products	6,514	7,288	6,933	8,251	7,214	6,445	7,215	6,746	7,114	6,867	6,060	6,868	83,515
Crude losses	408	371	408	396	411	416	425	422	407	425	401	407	4,897
Domestic demand for products:													
Gasoline:													
Motor gasoline	189,647	180,223	201,901	196,243	214,125	208,912	217,717	224,735	197,417	206,984	204,688	192,909	2,435,501
Aviation gasoline	1,225	1,236	1,315	1,277	1,572	1,349	1,202	1,913	1,324	1,575	1,361	1,182	16,531
Total gasoline	190,872	181,459	203,216	197,520	215,697	210,261	218,919	226,648	198,741	208,559	206,049	194,091	2,452,032
Jet fuel:													
Naphtha type	6,072	5,312	5,869	7,437	6,818	6,711	6,134	7,241	6,413	7,905	5,892	7,416	79,220
Kerosine type	28,337	25,215	24,935	23,007	27,667	23,490	26,263	25,283	25,527	25,145	24,501	24,765	304,135
Total jet fuel	34,409	30,527	30,804	30,444	34,485	30,201	32,397	32,524	31,940	33,050	30,393	32,181	383,355
Ethane (including ethylene)	9,634	9,089	10,414	9,796	9,882	9,694	9,633	10,224	9,568	10,083	10,789	10,637	119,443
Liquefied gases:													
LRG [6] for fuel use	8,161	7,773	7,209	7,437	7,919	6,536	7,866	7,210	7,511	7,037	7,549	7,446	89,654
LRG [6] for chemical use	3,240	2,863	3,295	3,043	3,405	3,049	3,389	3,313	3,378	3,280	2,937	2,848	38,040
LPG [7] for fuel and chemical use	40,780	32,267	22,653	18,613	18,099	15,194	13,314	18,545	18,195	25,632	29,519	28,611	281,422
Total liquefied gases	52,181	42,903	33,157	29,093	29,423	24,779	24,569	29,068	29,084	35,949	40,005	38,905	409,116
Kerosine	12,585	10,784	6,222	4,894	4,102	3,529	4,602	4,546	5,534	5,563	9,168	7,386	78,915
Distillate fuel oil	128,150	118,790	102,732	79,040	82,216	72,360	72,184	79,168	79,785	90,386	105,255	114,242	1,124,308
Residual fuel oil	101,123	92,538	95,209	74,164	78,054	78,046	74,700	83,392	79,996	78,956	93,552	90,204	1,019,934
Petrochemical feedstocks: [8]													
Still gas	1,327	840	1,183	1,019	1,222	1,054	916	1,188	1,015	884	902	878	12,428
Naphtha–400°	4,954	4,447	4,380	4,700	4,286	4,230	4,718	4,775	4,790	4,811	5,339	5,392	56,822
Other	4,964	4,515	5,197	5,553	4,815	5,319	5,264	5,343	4,934	5,130	5,102	5,581	61,717
Total petrochemical feedstocks	11,245	9,802	10,760	11,272	10,323	10,603	10,898	11,306	10,739	10,825	11,343	11,851	130,967
Special naphthas	2,793	2,697	2,806	2,045	3,129	2,630	2,714	2,956	2,499	2,995	2,453	2,513	32,230
Lubricants	4,609	4,556	4,911	4,353	5,142	4,473	5,424	5,279	4,623	5,693	5,046	4,928	59,037
Wax	518	484	591	463	646	553	521	666	584	650	687	578	6,941
Coke	8,370	6,887	7,522	7,208	8,010	8,401	8,285	8,640	7,490	8,875	7,603	7,835	95,126
Asphalt	5,592	5,400	8,084	11,314	16,110	20,061	23,429	26,123	21,068	20,944	15,140	9,337	182,602
Road oil	101	92	191	242	742	1,246	1,278	1,540	967	847	448	138	7,832
Still gas	15,018	13,129	14,901	14,420	14,854	15,665	16,258	15,911	14,487	14,768	13,369	13,978	176,758
Miscellaneous products	1,471	1,201	1,458	1,438	1,865	1,629	1,535	1,840	1,483	1,804	1,732	1,482	18,938
Total domestic demand	578,671	530,338	532,978	477,706	514,680	494,131	507,346	539,831	498,588	529,947	553,032	540,286	6,297,534

See footnotes at end of table.

Table 3.—Supply, demand and stocks of all oils in the United States, by month—Continued

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Stocks all oils:													
Crude oil and lease condensate	237,469	235,362	244,131	248,783	257,867	248,857	243,673	248,314	241,276	246,297	249,998	242,478	242,478
Unfinished oils	87,767	87,583	97,646	104,956	105,404	103,615	102,307	98,925	101,904	102,499	103,586	99,154	99,154
Natural gasoline and plant condensate [9]	6,189	6,105	5,956	6,670	7,318	7,364	7,170	7,493	7,465	7,764	8,069	7,835	7,835
Refined products	574,286	537,829	539,653	552.891	563.110	598.175	633.148	642,223	664,996	680,880	661,585	658,840	658,840
Total	905,711	866,879	887,386	913,300	933,699	958,011	986,298	996,955	1,015,641	1,037,440	1,023,238	1,008,307	1,008,307

[p] Preliminary (except for oil and lease condensate production).
[1] U. S. Department of the Interior data for crude oil, unfinished oils, and plant condensate; U. S. Department of Commerce data for all other imports.
[2] Excludes imports for substitute natural gas (SNG) plant feedstock use.
[3] Represents the difference between supply and indicated demand for crude petroleum.
[4] Minus represents withdrawal from stock, which is added to total disposition; plus represents stocks increase, which is subtracted from total disposition.
[5] U. S. Department of Commerce data.
[6] Liquefied refinery gas.
[7] Liquefied petroleum gas.
[8] Produced at petroleum refineries. Data for LPG for petrochemical feedstocks are included with those for "Liquefied gases."
[9] Includes isopentane.

Tabe 4.—Supply, demand and stocks of all oils by PAD Districts in 1973

(Thousand barrels)

	P.A.D. Districts						
	I	II	III	IV	Total	V	United States
Domestic production:							
Crude oil and lease condensate	39,329	353,520	2,312,976	245,780	2,951,605	409,298	3,360,903
Natural gas plant liquids	8,554	89,956	505,906	17,101	621,517	12,906	634,423
Receipts from other districts	1,112,463	988,409	65,028	20,377	10,305	60,677	--
Imports:							
Plant condensate	1,777	22,534	--	10,115	34,426	3,049	[1] 37,475
Crude oil	466,074	260,368	145,654	16,132	888,228	295,768	1,183,996
Unfinished oils	26,216	739	10,681	--	37,636	12,525	50,161
Refined products	860,546	29,323	44,715	6,156	940,740	51,151	991,891
Other hydrocarbons and hydrogen input	555	612	4,719	88	5,974	4,742	10,716
Total new supply	2,515,514	1,745,461	3,089,679	315,749	5,490,431	850,116	6,269,565
Unaccounted for crude oil	123	4,766	−7,702	3,038	225	693	918
Processing gain	20,311	46,275	67,065	2,242	135,893	29,595	165,488
Total supply	2,535,948	1,796,502	3,149,042	321,029	5,626,549	880,404	6,435,971
Change in stocks, all oil [2]	+26,399	+25,349	+9,639	+3,165	+64,552	−15,224	+49,328
Total disposition of primary supply	2,509,549	1,771,153	3,139,403	317,864	5,561,997	895,628	6,386,643

Exports:							
Crude oil	--	--	177	--	177	520	697
Refined products	6,198	3,482	37,477	46	47,203	36,312	83,515
Shipments to other districts	83,165	69,425	1,932,756	151,303	60,677	10,305	--
Crude losses	e 1,139	e 1,470	e 1,439	e 564	4,612	285	4,897
Domestic demand for products:							
Gasoline:							
Motor gasoline	810,515	843,808	352,485	74,172	2,080,980	354,521	2,435,501
Aviation gasoline	3,793	4,325	3,959	687	12,764	3,767	16,531
Total gasoline	814,308	848,133	356,444	74,859	2,093,744	358,288	2,452,032
Jet fuel:							
Naphtha type	22,552	13,180	16,693	2,878	55,303	23,917	79,220
Kerosine type	127,404	61,632	19,504	8,320	216,860	87,275	304,135
Total jet fuel	149,956	74,812	36,197	11,198	272,163	111,192	383,355
Ethane (including ethylene)	1,779	13,399	103,713	44	118,935	508	119,443
Liquefied gases	65,292	125,661	186,841	10,389	388,183	20,933	409,116
Kerosine	32,853	23,577	19,224	1,985	77,639	1,276	78,915
Distillate fuel oil	520,668	331,903	123,762	34,782	1,011,115	113,193	1,124,308
Residual fuel oil	700,170	86,052	70,549	9,457	866,228	153,706	1,019,934
Petrochemical feedstocks	9,626	13,847	100,178	216	123,867	7,100	130,967
Special naphthas	7,477	9,379	10,138	149	27,143	5,087	32,230
Lubricants	23,923	14,281	14,639	48	52,891	6,146	59,037
Wax	2,836	1,167	1,879	73	5,955	986	6,941
Coke	11,361	35,852	31,764	3,953	82,930	12,196	95,126
Asphalt	51,636	64,202	33,395	12,265	161,498	21,104	182,602
Road oil	659	4,332	64	830	5,885	1,947	7,832
Still gas for fuel	22,702	46,233	70,071	5,471	144,477	32,281	176,758
Miscellaneous products	3,801	3,946	8,696	232	16,675	2,263	18,938
Total domestic demand	2,419,047	1,696,776	1,167,554	165,951	5,449,328	848,206	6,297,534
Stocks of all oils:							
Crude oil and lease condensate	18,118	67,425	108,705	13,231	207,479	34,999	242,478
Unfinished oils	15,712	20,126	36,709	2,795	75,342	23,812	99,154
Natural gasoline and plant condensate	14	2,278	5,061	392	7,745	90	7,835
Refined products	195,946	194,658	184,676	17,805	593,085	65,755	658,840
Total	229,790	284,487	335,151	34,223	883,651	124,656	1,008,307

e Estimate.
[1] Excludes imports for substitute natural gas (SNG) plant feedstock use.
[2] Minus represents withdrawal from stocks, which is added to total disposition; plus represents stocks increase, which is subtracted from total disposition.

Table 5.—Estimates of proved crude oil reserves in the United States on December 31, by State[1]

(Million barrels)

State	1969	1970	1971	1972	1973
Eastern States:					
Illinois	272	229	209	175	152
Indiana	41	37	31	29	27
Kentucky	73	61	52	48	40
Michigan	52	46	59	62	72
New York	12	11	10	9	8
Ohio	127	128	129	127	125
Pennsylvania	55	51	47	37	40
West Virginia	53	53	52	34	32
Total	685	616	589	521	496
Central and Southern States:					
Alabama	67	65	61	57	54
Arkansas	127	130	118	113	106
Florida	(2)	(2)	204	208	184
Kansas	566	539	502	453	401
Louisiana[3]	5,689	5,710	5,399	5,029	4,577
Mississippi	360	355	342	313	291
Nebraska	47	41	36	31	28
New Mexico	840	761	657	583	643
North Dakota	235	192	174	166	179
Oklahoma	1,390	1,351	1,405	1,303	1,271
Texas[3]	13,063	13,195	13,023	12,144	11,757
Total	22,384	22,339	21,921	20,400	19,491
Mountain States:					
Colorado	401	389	333	326	305
Montana	276	242	228	241	219
Utah	195	182	166	244	264
Wyoming	997	1,017	997	950	917
Total	1,869	1,830	1,724	1,761	1,705
Pacific Coast States:					
Alaska	432	[4] 10,149	[4] 10,116	[4] 10,096	[4] 10,112
California[3]	4,243	3,984	3,706	3,554	3,488
Total	4,675	14,133	13,822	13,650	13,600
Other States[5]	19	83	7	7	8
Total United States	29,632	39,001	38,063	36,339	35,300

[1] From reports of Committee of Petroleum Reserves, American Petroleum Institute. Included are estimated quantities of crude oil which geological and engineering data demonstrate with reasonable certainty to be recoverable from known reservoirs under existing economic and operating conditions.
[2] Included with "Other States."
[3] Includes offshore reserves.
[4] These data include the estimate of proved reserves in the Prudhoe Bay Permo-Triassic reservoir, discovered in 1968. The estimate is based on the analysis of extensive engineering and geologic data; however, revisions may be required when actual production performance becomes available.
[5] Includes Arizona, Missouri, Nevada, South Dakota, Tennessee, and Virginia.

Table 6.—Supply and disposition of crude petroleum (including lease condensate) in the United States

(Thousand barrels)

Supply and disposition	1969	1970	1971	1972	1973 p
Supply:					
Production	3,371,751	3,517,450	3,453,914	3,455,368	3,360,903
Imports[1]	514,114	483,293	613,417	811,135	1,183,996
Total new supply	3,885,865	4,000,743	4,067,331	4,266,503	4,544,899
Stock changes:[2]					
Domestic crude	−4,668	+10,380	−23,239	−17,064	−9,964
Foreign crude	−2,298	+760	+6,520	+3,811	+6,047
Unaccounted for[3]	−2,561	−7,721	+14,823	+10,201	+918
Disposition by use:					
Runs of domestic crude	3,363,602	3,485,332	3,481,543	3,473,880	3,359,946
Runs of foreign crude	516,003	482,171	606,266	806,983	1,177,308
Exports[4]	1,436	4,991	503	187	697
Transfers:					
Distillate	654	743	1,548	944	760
Residual	4,334	4,317	4,565	3,322	6,126
Losses	4,241	4,328	4,448	4,641	4,897
Total disposition by use	3,890,270	3,981,882	4,098,873	4,289,957	4,549,734

p Preliminary except for crude petroleum production.
[1] Bureau of Mines data.
[2] Minus represents withdrawal from stock; plus represents stock increase.
[3] Represents the difference between supply and indicated demand for crude petroleum.
[4] U.S. Department of Commerce data.

Table 7.–Supply and disposition of crude petroleum (including lease condensate) in the United States, by month

(Thousand barrels)

Supply and disposition	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1972													
Supply:													
Production	282,543	270,749	293,311	285,389	298,043	285,646	294,385	293,958	285,249	293,929	282,793	289,373	3,455,368
Imports [1]	63,419	60,344	64,066	60,129	66,958	62,544	67,635	65,463	70,909	78,003	68,978	82,687	811,135
Total new supply	345,962	331,093	357,377	345,518	365,001	348,190	362,020	359,421	356,158	371,932	351,771	372,060	4,266,503
Change in stocks, end of period:													
Domestic crude	−7,727	+2,899	+5,379	+4,948	+8,886	−4,812	−8,055	−7,108	−4,248	+1,102	+1,408	−9,736	−17,064
Foreign crude	−909	−966	+578	+2,786	+3,968	−3,297	+2,517	−759	−2,926	+1,844	−3,850	+4,825	+3,811
Unaccounted for [2]	−831	+853	+963	−1,387	+4,381	−315	+1,645	+2,852	+793	−214	+2,130	−669	+10,201
Disposition by use:													
Runs of domestic crude	288,758	268,078	288,230	278,197	292,840	289,416	303,350	303,162	289,560	291,916	282,723	297,650	3,473,880
Runs of foreign crude	64,277	61,254	63,473	57,336	62,966	65,820	65,095	66,215	73,804	76,083	72,815	77,845	806,983
Exports [3]	--	--	--	187	--	--	--	--	--	--	--	--	187
Transfers:													
Distillate	72	60	46	68	81	88	91	92	89	66	105	86	944
Residual	277	262	252	243	255	275	268	272	279	309	314	316	3,322
Losses	383	359	382	366	386	385	399	399	393	398	386	405	4,641
Total disposition by use	353,767	330,013	352,383	336,397	356,528	355,984	369,203	370,140	364,125	368,772	356,343	376,302	4,289,957
1973 p													
Supply:													
Production	284,454	263,066	287,430	278,757	287,134	276,418	285,731	284,225	271,959	285,940	274,829	280,960	3,360,903
Imports [1]	84,693	80,433	98,021	91,459	99,654	96,613	108,530	111,368	104,117	115,905	103,570	89,633	1,183,996
Total new supply	369,147	343,499	385,451	370,216	386,788	373,031	394,261	395,593	376,076	401,845	378,399	370,593	4,544,899
Change in stocks, end of period:													
Domestic crude	−8,435	−2,058	+5,849	+4,663	+8,460	−6,452	−9,188	+609	−4,009	+2,016	+999	−2,418	−9,964
Foreign crude	−491	−49	+2,920	−11	+624	−2,558	+4,004	+4,032	−3,029	+3,005	+2,702	−5,102	+6,047
Unaccounted for [2]	+612	−3,637	+2,352	+1,466	+3,924	+5,041	−2,979	+2,046	−5,121	−110	−2,337	−339	+918
Disposition by use:													
Runs of domestic crude	292,755	260,792	283,168	274,790	281,760	286,783	290,839	284,383	269,706	282,613	270,389	281,968	3,359,946
Runs of foreign crude	85,148	80,452	95,053	91,449	98,942	99,086	104,397	107,316	107,083	112,878	100,835	94,669	1,177,308
Exports [3]	--	--	--	--	128	--	232	--	160	--	--	177	697
Transfers:													
Distillate	44	42	76	69	67	68	81	64	69	76	46	58	760
Residual	330	312	329	326	320	729	492	813	568	722	690	495	6,126
Losses	408	371	408	396	411	416	425	422	407	425	401	407	4,897
Total disposition by use	378,685	341,969	379,034	367,030	381,628	387,082	396,466	392,998	377,993	396,714	372,361	377,774	4,549,734

p Preliminary except for crude petroleum production.
[1] Reported to the Bureau of Mines. Imports of crude oil include some Athabasca hydrocarbons.
[2] Represents the difference between supply and indicated demand for crude petroleum.
[3] U. S. Department of Commerce.

Table 8.—Production of crude petroleum (including lease condensate) in the United States, by State and month

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1972													
Alabama	730	697	782	784	838	818	892	907	879	882	857	868	9,934
Alaska	6,423	5,448	6,261	6,066	6,228	6,085	6,276	6,059	5,883	6,124	5,946	6,094	72,893
Arizona	89	83	87	80	86	83	87	89	86	79	64	80	993
Arkansas	1,521	1,463	1,570	1,523	1,582	1,531	1,584	1,577	1,526	1,588	1,501	1,553	18,519
California	29,398	27,759	29,515	28,592	29,637	28,471	29,421	29,479	28,388	29,315	28,286	28,761	347,022
Colorado	2,239	2,215	2,445	2,390	2,587	2,523	2,641	2,760	2,868	2,866	3,158	3,323	32,015
Florida	532	554	621	958	1,178	1,126	1,497	1,774	1,954	1,922	2,201	2,580	16,897
Illinois	3,198	2,874	3,071	2,828	3,044	2,912	2,859	2,976	2,769	2,869	2,798	2,676	34,874
Indiana	614	483	525	471	522	495	503	544	512	534	482	445	6,130
Kansas	6,204	6,159	6,594	6,196	6,513	6,183	6,154	6,272	5,980	6,078	5,702	5,709	73,744
Kentucky	820	794	855	778	869	826	809	846	772	812	779	742	9,702
Louisiana	76,022	70,297	76,219	73,515	77,131	73,381	75,389	75,435	73,000	75,331	72,362	73,745	891,827
Michigan	1,055	917	994	1,021	1,077	1,076	1,121	1,175	1,158	1,218	1,098	1,080	12,990
Mississippi	5,017	4,760	5,195	5,166	5,306	5,108	5,251	5,233	4,964	5,083	4,895	5,122	61,100
Missouri	5	5	5	5	5	5	5	5	5	5	5	5	60
Montana	2,729	2,624	2,888	2,823	2,906	2,819	2,900	2,855	2,775	2,891	2,798	2,896	33,904
Nebraska	794	743	776	755	763	722	724	719	686	710	662	651	8,705
Nevada	8	8	9	7	9	8	6	7	9	10	8	11	100
New Mexico	9,664	9,068	9,599	9,344	9,526	8,988	9,287	9,286	8,859	9,179	8,815	8,910	110,525
New York	96	88	92	66	90	93	108	72	81	85	74	73	1,018
North Dakota	1,754	1,654	1,791	1,693	1,728	1,698	1,730	1,722	1,696	1,737	1,685	1,736	20,624
Ohio	870	808	805	709	788	799	785	866	721	755	721	731	9,358
Oklahoma	17,696	18,017	17,464	16,921	18,073	17,112	17,967	16,708	17,108	17,165	16,480	16,922	207,633
Pennsylvania	289	266	262	260	304	289	283	302	279	325	294	288	3,441
South Dakota	14	13	23	20	20	18	17	20	18	20	17	19	219
Tennessee	17	15	17	16	17	16	17	17	16	17	16	17	198
Texas	99,641	98,377	109,422	108,688	113,071	108,659	112,117	112,152	108,444	112,219	108,070	110,825	1,301,685
Utah	2,196	2,115	2,282	2,204	2,147	2,238	2,193	2,282	2,275	2,281	2,282	2,075	26,570
West Virginia	222	209	243	219	229	240	220	237	215	224	214	205	2,677
Wyoming	12,686	12,236	12,899	11,291	11,769	11,324	11,542	11,582	11,323	11,605	10,523	11,231	140,011
Total: 1972	282,543	270,749	293,311	285,389	298,043	285,646	294,385	293,958	285,249	293,929	282,793	289,373	3,455,368
1971	299,305	272,404	302,809	293,068	298,980	288,117	293,154	291,730	274,057	284,032	274,170	282,088	3,453,914
Daily average, 1972	9,114	9,336	9,462	9,513	9,614	9,522	9,496	9,483	9,508	9,482	9,426	9,335	9,441
Pennsylvania grade (included in United States Total)	1,232	1,155	1,121	1,013	1,120	1,127	1,108	1,146	1,016	1,097	1,016	1,025	13,176
1973													
Alabama	839	871	1,041	1,024	1,007	978	1,039	954	974	978	969	1,003	11,677
Alaska	6,033	6,061	5,386	5,901	6,195	5,937	6,248	6,425	6,018	6,213	5,844	6,062	72,323
Arizona	76	74	76	72	65	69	62	68	63	58	58	63	804
Arkansas	1,547	1,427	1,522	1,508	1,510	1,462	1,517	1,547	1,537	1,531	1,439	1,469	18,016
California:													
South	11,518	10,495	11,565	11,043	11,292	10,880	11,142	11,095	10,659	10,949	10,630	10,924	132,192

Central Coastal	6,609	6,031	6,701	6,471	6,708	6,614	6,783	6,748	6,423	6,685	6,410	6,537	78,720
East Central	10,494	9,494	10,511	10,243	10,626	10,253	10,482	10,532	10,147	10,657	10,297	10,722	124,458
North	65	57	61	60	62	56	54	59	57	57	59	58	705
Total California	28,686	26,077	28,838	27,817	28,688	27,803	28,461	28,434	27,286	28,348	27,396	28,241	336,075
Colorado	2,883	2,715	2,821	2,858	3,027	3,098	3,507	2,826	3,188	3,295	3,202	3,170	36,590
Florida	2,583	2,627	2,918	2,713	2,770	2,585	2,692	2,767	2,719	2,769	2,758	2,794	32,695
Illinois	2,779	2,416	2,748	2,616	2,747	2,506	2,511	2,601	2,423	2,576	2,442	2,304	30,669
Indiana	456	424	464	435	460	422	467	445	417	462	444	416	5,312
Kansas	5,677	5,416	5,605	5,669	5,925	5,628	5,557	5,672	5,212	5,664	5,269	4,933	66,227
Kentucky	713	807	786	765	726	705	736	750	659	746	639	655	8,687
Louisiana:													
Gulf Coast	69,385	62,417	69,230	66,836	67,940	65,705	68,287	66,949	60,463	66,215	63,685	64,648	791,760
Rest of State	3,544	3,223	3,449	3,020	3,013	3,069	3,327	3,444	3,304	3,465	3,383	3,523	39,764
Total Louisiana	72,929	65,640	72,679	69,856	70,953	68,774	71,614	70,393	63,767	69,680	67,068	68,171	831,524
Michigan	1,171	1,069	1,020	1,219	1,272	1,202	1,253	1,267	1,206	1,310	1,245	1,380	14,614
Mississippi	5,024	4,314	4,848	4,633	4,751	4,571	4,768	4,787	4,606	4,669	4,520	4,611	56,102
Missouri	5	5	5	5	5	5	5	5	5	5	5	5	60
Montana	2,866	2,501	2,963	2,807	2,997	2,863	2,887	2,921	2,868	3,035	2,911	3,001	34,620
Nebraska	653	591	602	589	630	614	622	623	579	600	575	562	7,240
Nevada	9	8	8	8	8	8	8	7	7	9	8	8	96
New Mexico:													
Southeastern	8,049	7,387	8,191	7,796	8,052	7,676	7,719	7,716	7,452	7,938	7,679	7,761	93,416
Northwestern	643	562	597	625	644	616	622	610	625	688	652	686	7,570
Total New Mexico	8,692	7,949	8,788	8,421	8,696	8,292	8,341	8,326	8,077	8,626	8,331	8,447	100,986
New York	72	64	74	84	90	84	86	84	82	86	81	80	967
North Dakota	1,723	1,602	1,684	1,655	1,783	1,638	1,687	1,701	1,690	1,728	1,682	1,662	20,235
Ohio	657	584	685	778	828	785	780	782	716	752	724	725	8,796
Oklahoma	15,917	17,071	16,080	15,292	16,376	15,748	16,217	15,579	16,228	15,955	14,885	15,856	191,204
Pennsylvania	278	265	252	238	295	280	283	293	262	304	272	260	3,282
South Dakota	18	17	17	17	18	18	19	28	28	30	34	31	275
Tennessee	17	16	17	16	17	16	18	18	16	17	16	17	201
Texas:													
District 01	1,893	1,721	1,901	1,805	1,831	1,712	1,763	1,746	1,676	1,720	1,661	1,714	21,143
District 02	6,637	5,976	6,665	6,511	6,694	6,371	6,558	6,580	6,332	6,501	6,233	6,391	77,449
District 03	14,996	13,631	15,335	14,781	15,009	14,333	14,883	14,856	14,349	14,876	14,204	14,594	175,847
District 04	5,178	4,745	5,418	5,279	5,297	5,056	5,120	5,019	4,754	4,859	4,638	4,728	60,091
District 05	2,787	2,554	2,760	2,675	2,772	2,710	2,791	2,819	2,668	2,784	2,690	2,753	32,763
District 06, except East Texas	6,757	6,287	6,942	6,678	6,744	6,503	6,623	6,761	6,524	6,756	6,485	6,725	79,785
East Texas	6,544	5,911	6,512	6,273	6,461	6,248	6,362	6,338	6,117	6,294	6,122	6,297	75,479
District 07B	3,051	2,873	3,192	3,020	3,116	2,976	3,030	3,024	2,925	3,037	2,962	3,026	36,232
District 07C	3,496	3,194	3,530	3,355	3,387	3,245	3,333	3,302	3,208	3,343	3,201	3,232	39,826
District 08	23,421	21,692	24,129	23,339	23,985	22,984	23,697	23,848	22,963	23,955	23,132	23,706	280,851
District 08A	27,776	25,573	28,734	27,884	29,076	27,855	29,912	29,970	29,130	30,581	29,785	30,758	346,984
District 09	3,918	3,663	4,078	3,921	3,992	3,816	3,862	3,839	3,699	3,805	3,669	3,688	45,950
District 10	1,882	1,799	1,964	1,850	1,957	1,859	1,873	1,847	1,775	1,866	1,778	1,821	22,271
Total Texas	108,336	99,619	111,160	107,371	110,321	105,668	109,807	109,949	106,120	110,377	106,510	109,433	1,294,671

See footnotes at end of table.

Table 8.—Production of crude petroleum (including lease condensate) in the United States, by State and month—Continued

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Utah	2,348	2,220	2,390	2,818	2,723	2,705	2,777	2,823	2,732	3,116	2,914	3,090	32,656
West Virginia	221	185	217	193	207	190	180	189	169	223	209	202	2,385
Wyoming	11,246	10,431	11,736	11,379	12,044	11,764	11,582	11,961	12,305	12,778	12,379	12,309	141,914
Total United States:													
1973	284,454	263,066	287,430	278,757	287,134	276,418	285,731	284,225	271,959	285,940	274,829	280,960	3,360,903
1972	282,543	270,749	293,311	285,389	298,043	285,646	294,385	293,958	285,249	293,929	282,793	289,373	3,455,368
Daily average, 1973	9,176	9,395	9,272	9,292	9,262	9,214	9,217	9,169	9,065	9,224	9,161	9,063	9,208
Pennsylvania grade (included in U.S. total)	941	847	926	1,002	1,095	1,034	1,034	1,058	970	1,122	1,034	1,027	12,090

Sources of 1973 data:

Alabama —Alabama State Oil and Gas Board.
Alaska —Alaska Department of Natural Resources.
Arizona —Arizona Oil & Gas Conservation Commission.
Arkansas —Arkansas Oil and Gas Commission.
California —Division of Oil and Gas, California Department of Conservation.
Colorado —Colorado Oil & Gas Conservation Commission.
Florida —Florida Department of Natural Resources.
Illinois —Illinois State Geological Survey.
Indiana —Indiana Department of Natural Resources.
Kansas —Kansas Corporation Commission.
Kentucky —Kentucky Geological Survey.
Louisiana —Louisiana Department of Conservation and U.S. Geological Survey.
Michigan —Geological Survey Division, Michigan Department of Natural Resources.
Mississippi —Mississippi State Oil and Gas Board.
Missouri —Missouri Geological Survey and Water Resources.
Montana —Montana Department of Natural Resources and Conservation.
Nebraska —Nebraska Oil and Gas Conservation Commission.
Nevada —Nevada Oil and Gas Conservation Commission.
New Mexico —New Mexico Oil Conservation Commission.
New York —New York State Geological Survey.
North Dakota—North Dakota Geological Survey.
Ohio —Ohio Department of Natural Resources.
Oklahoma —Oklahoma Corporation Commission and Oklahoma Tax Commission.
Pennsylvania —Bureau of Topographic and Geologic Survey, Pennsylvania Department of Environmental Resources.
South Dakota—South Dakota Geological Survey.
Tennessee —Division of Geology, Tennessee Department of Conservation.
Texas —Oil and Gas Division, The Railroad Commission of Texas.
Utah —Utah Oil and Gas Conservation Commission.
West Virginia—West Virginia Department of Mines.
Wyoming —Wyoming Oil and Gas Conservation Commission.

Table 9.—Percentage of total U.S. crude petroleum produced, by State

State	1969	1970	1971	1972	1973
Texas	34.2	35.5	35.4	37.7	38.5
Louisiana	r 25.1	25.8	27.1	25.8	24.7
California	11.1	10.6	10.4	10.0	10.0
Oklahoma	6.7	6.4	6.2	6.0	5.7
Wyoming	4.6	4.6	4.3	r 4.0	4.2
New Mexico	3.8	3.6	3.4	3.2	3.0
Alaska	2.2	2.4	2.3	2.1	2.2
Kansas	2.6	2.4	2.3	2.1	2.0
Mississippi	1.9	r 1.8	1.9	1.8	1.7
Colorado	r.9	.7	.8	.9	1.1
Montana	1.3	1.1	1.0	1.0	1.0
Florida	(1)	.1	.2	.5	1.0
Utah	.7	.7	.7	.8	1.0
Illinois	1.5	1.2	1.1	1.0	.9
North Dakota	.7	.6	.6	.6	.6
Arkansas	.5	.5	.5	.5	.5
Michigan	.4	.3	.3	.4	.4
Alabama	.2	.2	.2	.3	.3
Ohio	.3	.3	.2	.3	.3
Other States	r 1.3	r 1.2	r 1.1	r 1.0	r.9
Total	100.0	100.0	100.0	100.0	100.0

r Revised.
[1] Less than 0.05 percent.

Table 10.—Production and reserves of crude petroleum in leading fields in the United States

(Thousand barrels)

Field [1]	State	Production 1972	Production 1973	Total since discovery [2]	Estimated reserves
Wasson	Texas	62,764	83,726	616,311	716,237
East Texas	do	77,702	75,436	4,169,403	1,830,597
Kelly-Snyder	do	63,554	70,944	540,039	568,073
Wilmington	California	70,117	67,066	1,549,496	763,317
Slaughter	Texas	39,933	45,486	548,432	241,568
Hawkins	do	37,271	39,513	496,067	328,933
McArthur River	Alaska	40,825	39,171	214,485	175,939
Midway Sunset	California	34,546	34,699	1,192,592	413,111
Sho-Vel-Tum	Oklahoma	33,800	33,320	968,206	181,794
Bay Marchand Block 2	Louisiana	29,390	32,561	396,912	253,098
Jay	Florida	13,870	27,977	42,217	270,783
Kern River	California	27,197	27,973	607,784	469,288
Tom O'Connor	Texas	29,635	27,895	470,743	229,257
Caillou Island	Louisiana	29,683	25,613	498,875	201,125
West Delta Block 30	do	25,144	24,626	289,876	160,124
Hastings, East and West	Texas	21,760	22,546	475,079	199,921
Conroe	do	17,278	21,846	518,922	156,078
Webster	do	20,515	20,894	388,196	186,804
Grand Isle Block 43	Louisiana	23,095	20,732	142,670	227,402
Huntington Beach	California	21,595	20,389	904,585	131,792
Spraberry Trend	Texas	20,617	20,383	361,443	148,557
Rangely	Colorado	11,668	19,378	491,337	108,663
Goldsmith All	Texas	19,015	19,298	561,227	113,773
Grand Isle Block 16	Louisiana	19,690	18,936	197,896	152,104
Yates	Texas	17,214	18,195	587,252	1,012,748
West Ranch	do	18,162	(3)	(3)	(3)
Fairway	do	18,095	17,175	109,962	89,975
Dos Cuadras	California	20,018	16,745	87,498	88,237
South Pass Block 24	Louisiana	18,227	16,740	356,253	133,747
Van and Van Shallow	Texas	16,105	16,658	403,120	146,880
Cowden South (Foster, Johnson)	do	15,271	16,075	282,899	117,101
Thompson (all fields)	do	15,607	15,858	353,752	146,248
Seminole All	do	11,451	15,475	199,245	115,755
Salt Creek	Wyoming	12,060	15,203	529,603	65,397
Main Pass Block 41	Louisiana	17,678	14,808	134,123	145,877
South Pass Block 27	do	17,312	13,366	247,358	137,642
Cowden North	Texas	10,757	13,091	261,866	63,134
Greater Altamont	Utah	(3)	13,069	24,367	250,333
San Ardo	California	10,816	12,609	261,332	86,636
Panhandle	Texas	13,810	12,579	1,271,238	143,762

See footnotes at end of table.

Table 10.—Production and reserves of crude petroleum in leading fields in the United States—Continued

(Thousand barrels)

Field [1]	State	Production 1972	Production 1973	Total since discovery [2]	Estimated reserves
Cogdell Area	Texas	14,054	12,255	177,681	142,319
South Pass Block 65	Louisiana	11,931	12,088	36,088	153,912
Salt Creek	Texas	13,054	12,014	113,570	116,430
Sooner Trend	Oklahoma	14,390	11,480	189,604	60,396
Oregon Basin	Wyoming	12,200	11,392	228,995	61,005
Ship Shoal Block 208	Louisiana	14,420	11,262	81,947	143,053
Levelland	Texas	10,041	11,201	220,117	104,883
Ventura	California	10,369	11,022	782,054	69,946
Anahuac	Texas	11,255	10,969	234,810	115,190
Main Pass Block 69	Louisiana	11,566	10,924	183,037	76,963
McElroy	Texas	10,289	10,772	296,698	62,302
Garden Island Bay	Louisiana	12,993	10,384	166,426	89,911
W. Cote Blanche Bay	do	13,908	10,288	139,436	110,564
Middle Ground Shoal	Alaska	9,639	10,259	78,682	106,033
Swanson River	do	8,874	10,059	144,551	60,938
Golden Trend	Oklahoma	11,955	9,875	393,876	106,124
Eugene Island Block 175	Louisiana	6,954	9,873	29,241	80,759
Empire Abo	New Mexico	8,735	9,797	98,904	71,096
Elk Basin	Montana, Wyoming	12,500	9,559	461,354	78,646
Weeks Island	Louisiana	11,053	9,486	139,729	96,271
Timbalier Bay	do	([3])	9,456	226,634	200,111
West Delta Block 73	do	16,250	9,348	120,565	154,435
Dune	Texas	11,332	9,181	119,028	80,972
South Pass Block 62	Louisiana	10,248	8,666	41,956	148,044
Belridge South	California	8,705	8,558	186,258	73,526
West Bay	Louisiana	9,040	8,363	169,864	70,136
Lafitte	do	9,333	8,211	206,805	51,190
West Delta Block 58	do	8,674	8,176	28,056	121,944
Black Bay West	do	9,113	8,036	84,470	65,530
Bell Creek	Montana	5,880	7,967	58,912	51,088
Baxterville	Mississippi	9,630	7,902	160,160	74,840
Hilight	Wyoming	7,800	7,896	42,090	92,910
Trading Bay	Alaska	8,690	7,830	48,902	25,505
Greater Aneth	Utah	7,470	7,814	251,515	63,485
Means All	Texas	7,889	7,677	139,605	70,395
Diamond M	do	7,769	7,547	190,164	84,836
Ward-Estes North	do	8,747	7,520	304,004	70,995
Tijerina-Canales-Blucher	do	6,623	7,094	96,661	68,339
Coalinga	California	7,702	7,062	626,495	72,370

[1] Fields under 7 million barrels not shown for current year.
[2] Includes revisions, if any.
[3] Not reported.

Source: Oil and Gas Journal. All figures are preliminary.

Table 11.—Well completions in the United States, by quarter [1]

	1st quarter	2nd quarter	3rd quarter	4th quarter	Total Number	Total Percent
1972:						
Oil	2,981	2,884	2,813	2,637	11,306	41.4
Gas [2]	1,021	1,081	1,212	1,614	4,928	18.1
Dry	2,690	2,497	2,703	3,184	11,057	40.5
Total	6,692	6,462	6,728	7,435	27,291	100.0
1973:						
Oil	2,474	2,219	2,497	2,701	9,902	37.2
Gas [2]	1,392	1,330	1,658	1,993	6,385	24.0
Dry	2,561	2,222	2,518	3,028	10,305	38.8
Total	6,427	5,771	6,673	7,722	26,592	100.0

[1] Excludes service wells.
[2] Includes condensate wells.
Note: Data by quarters do not agree with annual totals because of revision during the year.

Source: American Petroleum Institute.

Table 12.—Well completions in the United States, by State and district[1]

State and district	1972				1973			
	Oil	Gas[2]	Dry	Total	Oil	Gas[2]	Dry	Total
Alabama	13	9	93	115	18	10	74	102
Alaska	12	2	12	26	20	3	11	34
Arizona	5	1	16	22	--	1	7	8
Arkansas	96	39	209	344	91	40	154	285
California	1,045	62	288	1,395	879	65	263	1,207
Colorado	300	124	581	1,005	228	148	464	840
Florida	65	--	44	109	24	--	43	67
Georgia	--	--	2	2	--	--	3	3
Idaho	--	--	--	--	--	--	6	6
Illinois	255	18	329	602	240	13	303	556
Indiana	92	5	172	269	67	8	164	239
Kansas	880	368	1,150	2,398	592	384	1,077	2,053
Kentucky	230	166	360	756	158	157	316	631
Louisiana:								
North	291	451	374	1,116	234	269	318	821
South	375	234	535	1,144	337	284	564	1,185
Offshore	253	133	419	805	287	231	380	898
Total Louisiana	919	818	1,328	3,065	858	784	1,262	2,904
Michigan	87	34	188	309	73	41	164	278
Mississippi	87	13	317	417	70	28	252	350
Missouri	--	--	3	3	--	--	9	9
Montana	83	125	545	753	46	123	473	642
Nebraska	48	2	242	292	33	--	130	163
Nevada	--	--	2	2	--	--	--	--
New Mexico:								
West	64	173	106	343	57	372	76	505
East	438	65	188	691	223	126	196	545
Total New Mexico	502	238	294	1,034	280	498	272	1,050
New York	96	22	12	130	97	27	24	148
North Dakota	23	--	76	99	40	--	82	122
Ohio	426	721	184	1,331	393	940	171	1,504
Oklahoma	1,025	341	934	2,300	898	539	844	2,281
Oregon	--	--	--	--	--	--	3	3
Pennsylvania	534	297	70	901	525	484	90	1,099
South Dakota	4	--	32	36	5	--	17	22
Tennessee	14	9	71	94	24	10	64	98
Texas:								
District 01	438	29	189	656	179	58	278	515
District 02	95	111	245	451	79	176	224	479
District 03	289	140	386	815	292	138	402	832
District 04	147	200	292	639	146	272	320	738
District 05	17	14	69	100	3	12	63	78
District 06	101	45	120	266	116	54	117	287
District 07B	388	54	480	922	323	96	447	866
District 07C	330	102	195	627	357	265	234	856
District 08	940	100	195	1,235	977	98	189	1,264
District 08A	474	3	158	635	667	24	156	847
District 09	620	19	329	968	433	80	357	870
District 10	122	114	63	299	107	182	105	394
Offshore	2	12	39	53	7	20	45	72
Total Texas	3,963	943	2,760	7,666	3,686	1,475	2,937	8,098
Utah	73	13	74	160	104	25	66	195
Virginia	--	18	--	18	--	7	2	9
West Virginia	84	488	102	674	72	514	115	701
Wyoming	345	52	567	964	381	61	443	885
Total United States	11,306	4,928	11,057	27,291	9,902	6,385	10,305	26,592

[1] Excludes service wells.
[2] Includes condensate wells.

Table 13.—Refinery receipts of domestic

(Thousand

Location of refineries receiving crude oil	Total receipts of domestic crude oil	Intrastate receipts	Interstate: PAD district I, total [1]	Interstate: PAD district II: Ill., Ind., Mich.	Kans.	Ky., Ohio, Tenn.	Nebr., N. Dak., S. Dak.	Okla.	Total
District I:									
Delaware, Maryland	5,357	--	4,551	--	--	--	--	--	--
Florida, Georgia, Virginia	1,411	--	--	--	--	--	--	--	--
New Jersey	28,472	--	--	--	--	--	--	--	--
New York	577	--	--	577	--	--	--	--	577
Pennsylvania:									
East	31,050	--	4,419	--	--	--	--	--	--
West	14,184	3,843	1,759	719	640	5,256	--	1,621	8,236
West Virginia	4,992	1,528	--	--	--	3,464	--	--	3,464
Total	86,043	5,371	10,729	1,296	640	8,720	--	1,621	12,277
District II:									
Illinois	313,207	16,834	--	--	1,993	--	2,068	24,896	28,957
Indiana	144,264	3,137	--	1,350	4,064	250	4,296	8,739	18,699
Kansas	127,577	62,669	--	--	--	--	592	21,642	22,234
Kentucky, Tennessee	54,311	3,247	12	10,355	--	12	--	--	10,367
Michigan	25,598	11,624	--	23	--	--	--	--	23
Minnesota, Wisconsin	6,093	--	--	--	--	--	4,894	--	4,894
Missouri, Nebraska	35,685	17	--	--	383	--	--	3,578	3,961
North Dakota	15,173	13,989	--	--	--	--	--	--	--
Ohio: East	10,178	590	--	1,242	--	--	--	--	1,242
West	117,873	--	--	9,165	--	--	--	2,806	11,971
Oklahoma	163,134	119,842	--	--	3,366	--	--	--	3,366
Total	1,013,093	231,949	12	22,135	9,806	262	11,850	61,661	105,714
District III:									
Alabama	11,281	1,238	4,333	--	--	--	--	--	--
Arkansas	17,804	13,380	--	--	--	--	--	--	--
Louisiana	516,533	409,747	6,448	--	--	--	--	2,412	2,412
Mississippi	93,203	14,357	--	--	--	--	--	--	--
New Mexico	16,999	16,819	--	--	--	--	--	--	--
Texas	1,045,438	863,495	12,240	--	438	--	--	4,234	4,672
Total	1,701,258	1,319,036	23,021	--	438	--	--	6,646	7,084
District IV:									
Colorado	14,185	3,091	--	--	--	--	--	--	--
Montana	30,341	10,534	--	--	--	--	--	--	--
Utah	42,231	15,979	--	--	--	--	23	--	23
Wyoming	48,694	46,947	--	--	--	--	--	--	--
Total	135,451	76,551	--	--	--	--	23	--	23
District V:									
California	398,759	340,567	--	--	--	--	--	--	--
Other States	27,126	17,956	--	--	--	--	--	--	--
Total	425,885	358,523	--	--	--	--	--	--	--
Total United States	3,361,730	1,991,430	33,762	23,431	10,884	8,982	11,873	69,928	125,098
Daily average	9,210	5,456	92	64	30	25	33	192	344

[1] Includes receipts from: Florida, 31,991; New York, 843; West Virginia, 928.
[2] Includes receipts from: Alaska, 50,307; Arizona, 65; California, 4,506; Nevada, 14.

crude oil in 1973, by State and district

barrels)

Receipts from: PAD district III, Ala., Ark., Miss.	La.	N. Mex.	Tex.	Total	PAD district IV, Colo.	Mont.	Utah	Wyo.	Total	PAD district V, total [2]	Total interstate receipts
--	806	--	--	806	--	--	--	--	--	--	5,357
1,327	--	--	84	1,411	--	--	--	--	--	--	1,411
4,048	11,071	--	13,353	28,472	--	--	--	--	--	--	28,472
--	--	--	--	--	--	--	--	--	--	--	577
5,470	2,125	--	19,036	26,631	--	--	--	--	--	--	31,050
--	--	--	--	--	--	346	--	--	346	--	10,341
--	--	--	--	--	--	--	--	--	--	--	3,464
10,845	14,002	--	32,473	57,320	--	346	--	--	346	--	80,672
10,058	87,172	48,580	105,791	251,601	2,805	3,096	102	9,812	15,815	--	296,373
--	14,008	10,615	58,395	83,018	2,218	13,720	--	23,472	39,410	--	141,127
--	--	25	15,646	15,671	5,358	1,638	472	19,535	27,003	--	64,908
303	35,650	--	3,835	39,788	--	--	--	897	897	--	51,064
--	5,557	--	74	5,631	--	--	--	8,320	8,320	--	13,974
--	--	--	--	--	--	1,199	--	--	1,199	--	6,093
--	--	4,331	25,223	29,554	--	--	--	2,153	2,153	--	35,668
--	--	--	--	--	119	1,065	--	--	1,184	--	1,184
--	4,733	--	2,276	7,009	--	80	--	1,257	1,337	--	9,588
3,925	36,830	1,441	60,897	103,093	--	--	--	2,809	2,809	--	117,873
--	--	1,377	38,516	39,893	--	--	33	--	33	--	43,292
14,286	183,950	66,369	310,653	575,258	10,500	20,798	607	68,255	100,160	--	781,144
5,710	--	--	--	5,710	--	--	--	--	--	--	10,043
--	1,323	--	3,101	4,424	--	--	--	--	--	--	4,424
16,233	--	--	81,693	97,926	--	--	--	--	--	--	106,786
--	78,620	--	226	78,846	--	--	--	--	--	--	78,846
--	--	--	--	--	35	--	145	--	180	--	180
6,247	139,780	14,913	--	160,940	875	--	3,216	--	4,091	--	181,943
28,190	219,723	14,913	85,020	347,846	910	--	3,361	--	4,271	--	382,222
--	--	--	--	--	--	793	1,753	8,548	11,094	--	11,094
--	--	--	--	--	--	--	--	19,807	19,807	--	19,807
--	--	11	--	11	18,631	--	--	7,574	26,205	13	26,252
--	--	--	--	--	866	654	227	--	1,747	--	1,747
--	--	11	--	11	19,497	1,447	1,980	35,929	58,853	13	58,900
--	--	1,688	--	1,688	24	--	10,242	--	10,266	46,238	58,192
--	--	--	--	--	--	--	529	--	529	8,641	9,170
--	--	1,688	--	1,688	24	--	10,771	--	10,795	54,879	67,362
53,321	417,675	82,981	428,146	982,123	30,931	22,591	16,719	104,184	174,425	54,892	1,370,300
146	1,144	227	1,173	2,690	85	62	46	285	478	150	3,754

Table 14.—Producing oil wells in the United States and average production per well per day, by State

State	Producing oil wells			
	1972		1973	
	Approximate number of oil wells producing Dec. 31	Average production per well per day (barrels) [1]	Approximate number of oil wells producing Dec. 31	Average production per well per day (barrels) [1]
Alabama	544	49.3	586	56.6
Alaska	193	1,088.3	192	1,029.3
Arizona	28	93.6	28	78.7
Arkansas	7,157	7.1	7,232	6.9
California:				
South	9,740	38.3	8,812	39.0
Central Coastal	5,386	39.3	5,762	38.7
East Central	24,069	14.5	23,991	14.2
North	59	31.2	61	32.2
Total California	39,254	24.0	38,626	23.6
Colorado	1,897	47.5	2,004	51.4
Florida	142	419.7	147	619.9
Illinois	24,716	3.8	24,309	3.4
Indiana	[2] 4,379	4.2	[2] 4,323	3.3
Kansas	41,055	4.8	41,520	4.4
Kentucky	14,616	1.8	14,416	1.6
Louisiana:				
Gulf Coast	[2] 13,624	167.7	[2] 13,086	162.4
Northern	[2] 14,138	9.0	[2] 14,783	7.5
Total Louisiana	[2] 27,762	89.3	[2] 27,869	81.9
Michigan	3,685	9.2	3,733	10.8
Mississippi	3,195	53.0	2,901	50.4
Montana	3,544	27.7	3,471	27.0
Nebraska	1,143	20.4	1,107	17.6
New Mexico:				
Southwestern	15,703	17.7	15,503	16.4
Northwestern	1,584	15.1	1,596	13.0
Total New Mexico	17,287	17.5	17,099	16.1
New York	5,427	.5	5,200	.5
North Dakota	1,401	39.3	1,404	39.5
Ohio	15,222	1.7	15,236	1.6
Oklahoma	73,745	7.6	72,880	7.1
Pennsylvania	32,596	.3	31,539	.3
South Dakota	29	19.3	27	26.9
Texas:				
District 01	10,333	6.4	9,851	5.7
District 02	4,926	44.4	4,589	44.6
District 03	10,650	45.0	9,610	47.6
District 04	7,427	23.7	6,680	23.3
District 05	2,682	31.9	2,400	35.3
District 06, except East Texas	5,210	43.1	4,974	42.9
East Texas	13,960	13.8	13,500	15.1
District 07B	11,140	9.1	10,203	9.3
District 07C	7,491	15.3	7,366	14.7
District 08	36,126	21.9	35,489	21.5
District 08A	17,423	49.4	17,126	55.0
District 09	27,522	4.8	25,514	4.7
District 10	12,343	5.3	11,788	5.1
Total Texas	167,233	20.9	159,090	21.7
Utah	890	82.5	989	95.2
West Virginia	[2] 12,136	.6	[2] 13,600	.5
Wyoming	[2] 8,950	42.7	[2] 7,642	46.9
Other States:				
Missouri	137	1.2	135	1.2
Nevada	6	45.5	6	43.8
Tennessee	73	7.2	67	7.9
Virginia	1	(3)	--	--
Total	217	4.4	208	4.6
Total United States	508,443	18.4	497,378	18.3

[1] Based on the average number of wells during the year.
[2] Estimated by Bureau of Mines; all other numbers of producing oil wells furnished by State agencies.
[3] Less than 500 barrels.

Table 15.—Crude runs to stills and refinery receipts of crude oil in 1973, by origin of the crude and method of transportation

(Thousand barrels)

District and State	Crude runs to stills	Refinery fuel use and losses	By State of origin of domestic crude	Change in refinery stocks	Refinery receipts of domestic crude- By receiving State and method of transportation: Interstate: Pipe-lines	Interstate: Tank cars and trucks	Interstate: Tankers and barges	Intrastate: Pipe-lines	Intrastate: Tank cars and trucks	Intrastate: Tankers and barges	Refinery receipts of foreign crude: Pipe-lines	Refinery receipts of foreign crude: Tankers and barges
District I:												
Delaware, Maryland	46,830	—1	--	—111	--	--	--	--	--	5,357	--	41,361
Florida, Georgia, Virginia	21,084	3	31,991	+193	--	--	--	--	706	705	--	19,869
New Jersey	217,863	--	--	+2,024	--	--	--	--	--	28,472	--	191,415
New York	36,681	--	843	—1	--	--	--	577	--	--	36,103	--
Pennsylvania: East	198,429	353	--	+1,748	--	--	--	--	--	31,050	--	169,480
West	22,133	12	3,843	—115	3,297	546	--	6,517	2,137	1,687	7,846	--
West Virginia	5,007	--	2,456	—15	1,484	44	--	2,623	626	215	--	--
Total	[1] 548,027	367	39,133	+3,723	4,781	590	--	9,717	3,469	67,486	43,949	422,125
District II:												
Illinois	376,358	83	37,874	+537	16,720	114	--	296,373	--	--	63,771	--
Indiana	179,439	30	3,137	+148	3,094	43	--	139,959	43	1,125	35,353	--
Kansas	136,242	87	73,553	+203	61,786	883	--	64,800	108	--	8,955	--
Kentucky, Tennessee	63,929	58	3,838	+139	2,596	651	--	40,812	54	10,198	9,815	--
Michigan	44,853	17	14,015	+137	9,439	2,185	--	13,974	--	--	19,409	--
Minnesota, Wisconsin	70,537	--	--	+154	--	--	--	6,093	--	--	64,598	--
Missouri, Nebraska	36,889	--	6,016	+1	17	--	--	35,561	107	--	1,205	--
North Dakota, South Dakota	17,922	--	19,863	—42	13,872	117	--	1,173	11	--	2,707	--
Ohio: East	19,938	--	590	—92	590	--	--	9,588	--	--	9,668	--
West	[2] 162,677	30	8,391	+76	--	--	--	117,873	--	--	44,910	--
Oklahoma	163,214	148	189,770	—53	116,233	3,609	--	43,292	--	--	175	--
Total	1,271,998	453	357,047	+1,208	224,347	7,602	--	769,498	323	11,323	260,566	--
District III:												
Alabama	11,519	114	12,159	—80	142	31	1,065	4,143	93	5,807	--	272
Arkansas	17,807	32	15,014	—35	12,772	608	--	4,318	106	--	--	--
Louisiana	533,662	66	827,422	—685	325,449	4,440	79,858	89,630	644	16,512	--	16,510
Mississippi	93,452	--	55,123	—249	12,534	1,823	--	78,846	--	--	--	--
New Mexico	16,932	18	99,800	+49	14,141	2,678	--	--	180	--	--	--
Texas	1,171,326	222	1,291,641	+2,762	832,966	9,508	21,021	87,799	111	94,033	--	128,872
Total	1,844,698	452	2,301,159	+1,762	1,198,004	19,088	101,944	264,736	1,134	116,352	--	145,654
District IV:												
Colorado	14,177	293	34,022	—259	1,807	1,284	--	9,150	1,944	--	26	--
Montana	43,465	18	33,125	—130	9,770	764	--	19,797	10	--	[3] 13,012	--
Utah	42,330	38	32,698	—14	7,901	8,078	--	24,937	1,315	--	123	--
Wyoming	51,549	1	151,131	—8	46,117	830	--	1,323	424	--	2,848	--
Total	151,521	350	250,976	—411	65,595	10,956	--	55,207	3,693	--	16,009	--
District V:												
California	575,677	184	345,073	—796	286,626	7,023	46,918	8,943	3,232	46,017	--	176,306
Other States [4]	145,333	101	68,342	+1,154	17,539	417	--	--	529	8,641	88,216	31,246
Total	721,010	285	413,415	+358	304,165	7,440	46,918	8,943	3,761	54,658	88,216	207,552
Total United States	4,537,254	1,907	3,361,730	+6,640	1,796,892	45,676	148,862	1,108,101	12,380	249,819	[5] 408,740	775,331
Daily average	12,431	5	9,210	+18	4,923	125	408	3,036	34	684	1,120	2,124

[1] Includes 308,981,000 barrels in Delaware River Valley.
[2] Includes some Athabasca hydrocarbons.
[3] Includes 28 by trucks.
[4] Alaska, Arizona, Hawaii, Nevada, Oregon, and Washington.
[5] Excludes crude oil imported for direct fuel use by pipeline.

Table 16.—Transportation of petroleum products by pipelines in the United States in 1973, by month

(Thousand barrels)

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	1972 total
Turned into lines:														
Gasoline: •														
Motor	135,811	130,722	141,670	142,561	152,075	147,579	159,720	156,929	147,681	149,388	146,749	144,421	1,755,306	1,632,196
Aviation	238	170	396	317	407	406	297	479	322	390	320	274	4,016	4,017
Total gasoline	136,049	130,892	142,066	142,878	152,482	147,985	160,017	157,408	148,003	149,778	147,069	144,695	1,759,322	1,636,213
Jet fuel:														
Naphtha type	1,218	1,211	1,679	1,410	1,407	1,348	1,433	929	1,149	1,120	1,194	1,014	15,112	18,404
Kerosine type	21,256	19,549	21,380	21,265	18,459	17,734	19,892	18,457	18,867	20,680	20,132	16,838	234,509	210,072
Total jet fuel	22,474	20,760	23,059	22,675	19,866	19,082	21,325	19,386	20,016	21,800	21,326	17,852	249,621	228,476
Kerosine	5,908	5,913	4,551	3,200	2,619	1,996	2,737	2,511	3,074	4,764	4,735	4,875	46,883	47,499
Distillate fuel oil	74,302	62,951	62,483	51,336	50,728	52,682	58,026	56,205	57,903	64,249	65,593	70,561	727,019	656,798
Natural gas liquids	38,646	34,541	35,440	34,482	34,670	33,630	37,930	39,882	36,676	36,899	37,002	38,202	438,000	399,176
Delivered from lines:														
Gasoline:														
Motor	136,061	129,154	141,643	141,168	152,613	146,930	158,964	160,029	145,505	151,322	148,165	145,167	1,756,721	1,634,925
Aviation	234	205	299	348	311	391	329	461	299	317	390	275	3,859	3,831
Total gasoline	136,295	129,359	141,942	141,516	152,924	147,321	159,293	160,490	145,804	151,639	148,555	145,442	1,760,580	1,638,756
Jet fuel:														
Naphtha type	1,385	1,115	1,574	1,573	1,425	1,450	1,332	1,090	1,092	1,200	1,068	1,033	15,337	18,263
Kerosine type	21,025	19,502	20,998	20,882	18,829	17,620	19,225	18,648	18,813	19,643	19,296	17,217	231,698	208,054
Total jet fuel	22,410	20,617	22,572	22,455	20,254	19,070	20,557	19,738	19,905	20,843	20,364	18,250	247,035	226,317
Kerosine	6,195	5,964	4,551	2,803	2,344	2,000	2,279	2,576	2,527	4,333	4,851	4,663	45,086	46,132
Distillate fuel oil	76,293	65,460	63,483	51,694	51,151	47,870	56,238	54,352	55,057	61,162	66,621	71,616	720,997	659,409
Natural gas liquids	40,793	34,092	35,211	34,600	34,878	32,746	36,027	38,859	34,660	35,427	36,384	37,551	431,228	397,326
Shortage or overage: [1]														
Gasoline:														
Motor	(348)	(81)	(460)	(140)	(437)	241	(258)	(509)	(35)	(396)	(325)	162	(2,586)	(2,192)
Aviation	1	14	25	1	9	27	3	32	8	19	(3)	25	161	171
Total gasoline	(347)	(67)	(435)	(139)	(428)	268	(255)	(477)	(27)	(377)	(328)	187	(2,425)	(2,021)
Jet fuel:														
Naphtha type	(5)	3	26	(20)	(41)	(19)	(28)	26	(70)	(7)	33	2	(100)	(10)
Kerosine type	333	189	57	305	59	246	163	223	181	315	291	307	2,669	1,786
Total jet fuel	328	192	83	285	18	227	135	249	111	308	324	309	2,569	1,776
Kerosine	123	186	282	262	167	46	94	76	105	90	85	92	1,608	1,539
Distillate fuel oil	(259)	(339)	135	184	(285)	369	180	21	28	(202)	(240)	(439)	(847)	(352)
Natural gas liquids	205	204	195	(1)	12	(46)	(7)	126	106	1	(22)	629	1,402	580
Stocks in lines and working tanks at end of month:														
Gasoline:														
Motor	43,894	45,543	46,030	47,563	47,462	47,870	48,884	46,293	48,504	46,966	45,875	44,967	44,967	43,796
Aviation	196	147	219	187	274	262	227	213	228	282	215	189	189	193
Total gasoline	44,090	45,690	46,249	47,750	47,736	48,132	49,111	46,506	48,732	47,248	46,090	45,156	45,156	43,989
Jet fuel:														
Naphtha type	539	632	711	568	591	508	637	450	577	504	597	576	576	701
Kerosine type	5,003	4,861	5,186	5,264	4,835	4,703	5,207	4,793	4,666	5,388	5,933	5,247	5,247	5,105
Total jet fuel	5,542	5,493	5,897	5,832	5,426	5,211	5,844	5,243	5,243	5,892	6,530	5,823	5,823	5,806
Kerosine	2,038	1,801	1,519	1,654	1,762	1,712	2,076	1,935	2,377	2,718	2,517	2,637	2,637	2,448
Distillate fuel oil	23,813	21,643	20,508	19,966	19,828	24,271	25,879	27,711	30,529	33,818	33,030	32,414	32,414	25,545
Natural gas liquids	13,843	14,088	14,122	14,005	13,785	14,715	16,625	17,522	19,432	20,903	21,543	21,565	21,565	16,195

[1] Figures in parentheses denote shortage.

Table 17.—Transportation of petroleum products by pipeline between PAD districts in the United States in 1973, by month

(Thousand barrels)

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	1972 total
From District I to District II:														
Gasoline:														
Motor	3,360	3,353	3,695	3,683	3,686	3,891	3,702	4,471	3,614	4,300	3,921	3,709	45,385	39,187
Aviation	6	--	9	--	7	6	--	6	7	6	6	--	53	52
Total gasoline	3,366	3,353	3,704	3,683	3,693	3,897	3,702	4,477	3,621	4,306	3,927	3,709	45,438	39,239
Jet fuel:														
Naphtha type	40	104	81	79	78	87	29	25	--	--	37	35	595	601
Kerosine type	296	276	216	105	86	79	91	131	115	229	216	177	2,017	1,510
Total jet fuel	336	380	297	184	164	166	120	156	115	229	253	212	2,612	2,111
Kerosine	62	13	38	24	17	17	8	20	32	50	72	50	403	546
Distillate fuel oil	1,014	825	1,013	872	926	887	1,025	796	880	1,167	1,266	991	11,662	9,831
From District II to District I:														
Gasoline (motor)	697	772	825	940	837	802	759	799	876	1,009	879	871	10,066	11,276
Jet fuel:														
Naphtha type	--	--	--	--	--	--	--	--	--	--	57	--	57	111
Kerosine type	--	--	--	--	--	--	--	--	--	--	--	--	--	76
Total jet fuel	--	--	--	--	--	--	--	--	--	--	57	--	57	187
Kerosine	22	1	--	3	--	--	--	--	--	7	16	--	49	--
Distillate fuel oil	148	127	110	61	62	63	38	65	55	101	81	69	980	795
Natural gas liquids	737	722	1,021	1,089	1,059	997	1,046	1,083	1,034	1,056	949	1,117	11,910	9,946
From District II to District III:														
Gasoline (motor)	1,636	1,645	1,842	1,460	1,419	1,484	1,499	1,651	1,414	1,540	1,446	1,555	18,591	19,000
Jet fuel:														
Naphtha type	40	--	--	--	--	--	--	--	--	1	--	--	41	518
Kerosine type	1	1	1	--	--	--	1	--	--	--	1	1	6	4
Total jet fuel	41	1	1	--	--	--	1	--	--	1	1	1	47	522
Distillate fuel oil	430	346	316	470	451	384	400	323	425	320	426	452	4,743	4,592
Natural gas liquids	192	161	227	248	249	270	329	286	322	346	307	330	3,267	2,640
From District II to District IV:														
Gasoline (motor)	--	--	--	--	--	--	--	--	--	--	314	360	674	--
Distillate fuel oil	--	--	--	--	--	--	--	--	--	--	65	27	92	--
From District III to District I:														
Gasoline														
Motor	23,632	21,183	26,052	26,410	28,141	26,400	32,892	33,308	27,730	30,205	26,636	27,027	329,616	306,852
Aviation	15	27	16	--	18	24	30	42	15	15	9	8	219	307
Total gasoline	23,647	21,210	26,068	26,410	28,159	26,424	32,922	33,350	27,745	30,220	26,645	27,035	329,835	307,159
Jet fuel:														
Naphtha type	30	55	26	105	50	76	50	62	57	62	58	116	747	1,067
Kerosine type	5,089	5,344	5,304	5,009	4,100	3,629	3,862	3,907	3,307	5,023	5,347	4,836	54,757	48,265
Total jet fuel	5,119	5,399	5,330	5,114	4,150	3,705	3,912	3,969	3,364	5,085	5,405	4,952	55,504	49,332
Kerosine	2,092	1,620	1,200	684	277	306	413	683	590	1,206	1,041	1,022	11,134	12,959
Distillate fuel oil	19,519	16,525	16,512	13,961	13,148	11,850	14,173	14,047	12,781	13,959	16,265	17,591	180,381	179,498
Natural gas liquids	2,824	2,386	1,114	1,069	917	903	1,396	1,620	1,200	1,337	1,471	1,875	18,112	16,603

Table 17.—Transportation of petroleum products by pipeline between PAD districts in the United States in 1973, by month—Continued

(Thousand barrels)

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	1972 total
From District III to District II:														
Gasoline:														
Motor	3,866	4,108	4,727	4,946	4,505	4,289	5,986	5,283	6,792	7,057	6,249	5,852	63,660	57,389
Aviation	45	87	135	57	146	129	111	123	50	115	94	105	1,197	1,199
Total gasoline	3,911	4,195	4,862	5,003	4,651	4,418	6,097	5,406	6,842	7,172	6,343	5,957	64,857	58,588
Jet fuel:														
Naphtha type	--	--	--	--	1	--	1	--	--	--	1	--	3	4
Kerosine type	379	205	435	484	193	409	546	644	389	250	174	503	4,611	4,956
Total jet fuel	379	205	435	484	194	409	547	644	389	250	175	503	4,614	4,960
Kerosine	124	84	219	49	95	147	6	105	262	534	525	355	2,505	1,741
Distillate fuel oil	1,984	1,608	1,309	1,212	1,084	2,867	2,390	3,574	3,573	3,744	4,496	3,097	30,938	13,197
Natural gas liquids	5,986	6,180	6,124	5,153	4,754	4,635	4,789	5,627	6,494	6,976	7,274	7,706	71,698	63,739
From District III to District IV:														
Gasoline:														
Motor	362	329	346	429	420	340	395	401	362	402	416	297	4,499	4,144
Aviation	18	21	20	21	22	25	24	30	20	24	20	15	260	226
Total gasoline	380	350	366	450	442	365	419	431	382	426	436	312	4,759	4,370
Jet fuel (kerosine type)	338	322	322	312	361	389	383	402	324	358	319	345	4,175	3,985
Kerosine	1	--	--	1	1	--	--	--	--	--	1	--	4	20
Distillate fuel oil	73	41	46	53	64	50	49	49	44	67	84	68	688	552
Natural gas liquids	211	153	112	135	95	46	39	58	51	73	131	155	1,259	1,159
From District III to District V:														
Gasoline (motor)	1,170	1,065	1,064	961	792	1,004	904	863	962	985	939	1,164	11,873	11,543
Jet fuel:														
Naphtha type	69	40	100	80	38	63	77	22	42	47	37	37	652	1,177
Kerosine type	78	72	69	81	57	77	100	124	105	133	75	85	1,056	1,938
Total jet fuel	147	112	169	161	95	140	177	146	147	180	112	122	1,708	3,115
Distillate fuel oil	353	321	339	371	356	388	419	522	394	364	383	322	4,532	3,850
From District IV to District II:														
Gasoline (motor)	340	318	386	336	407	425	433	525	352	296	304	430	4,552	4,679
Jet fuel (naphtha type)	40	27	40	30	15	33	29	--	32	16	32	16	310	588
Kerosine	8	3	4	4	3	4	7	6	5	7	6	2	59	52
Distillate fuel oil	279	253	285	272	337	299	295	245	214	243	262	320	3,304	3,390
From District IV to District III:														
Natural gas liquids	--	266	280	311	350	342	346	331	316	306	293	285	3,426	3,096
From District IV to District V:														
Gasoline (motor)	646	734	756	599	606	603	523	709	675	562	797	595	7,805	9,250
Jet fuel:														
Naphtha type	36	12	58	17	40	4	51	8	17	31	8	69	351	880
Kerosine type	30	12	71	82	42	5	33	67	33	55	37	10	477	445
Total jet fuel	66	24	129	99	82	9	84	75	50	86	45	79	828	1,325
Distillate fuel oil	285	234	147	243	267	292	384	293	245	417	425	440	3,672	4,270

Table 18.—Pipeline tariff rates for crude petroleum and products, January 1

(Cents per barrel)

Origin	Destination	1973	1974
Crude oil:			
West Texas	Houston, Tex	$0.15–$0.18	$0.16–$0.18
Do	East Chicago, Ind	.28	.29
Do	Wood River, Ill	.28	.29
Oklahoma	Chicago, Ill	.22	.23
Do	Wood River, Ill	.19	.19
Eastern Wyoming	Chicago, Ill	.35	.35
Do	Wood River, Ill	.32	.32
Refined products:			
Houston, Tex	Atlanta, Ga	.36	.38
Do	New York, N. Y	.32	.35
Tulsa, Okla	Minneapolis, Minn	.74	.74
Salt Lake City, Utah	Spokane, Wash	.54	.54
Philadelphia, Pa	Rochester, N. Y	.24	.25

Source: Interstate Commerce Commission.

Table 19.—Receipts of domestic and foreign crude petroleum at refineries in the United States

(Million barrels)

Method of transportation	1969	1970	1971	1972	1973 p
By water:					
Intrastate	138.0	148.2	160.9	155.4	148.9
Interstate	408.8	461.8	430.0	298.5	249.8
Foreign	314.7	244.0	352.6	490.5	775.3
Total by water	861.5	854.0	943.5	944.4	1,174.0
By pipeline:					
Intrastate	1,715.1	1,730.5	1,702.2	1,832.0	1,796.9
Interstate	1,054.9	1,109.4	1,132.3	1,131.8	1,108.1
Foreign	199.2	236.8	260.4	317.8	408.7
Total by pipeline	2,969.2	3,076.7	3,094.9	3,281.6	3,313.7
By tank cars and trucks:					
Intrastate	41.8	37.1	37.0	47.5	45.7
Interstate	6.0	5.5	5.4	5.7	12.4
Foreign	--	--	--	--	--
Total by tank cars and trucks	47.8	42.6	42.4	53.2	58.1
Grand total	3,878.5	3,973.3	4,080.8	4,279.2	4,545.8

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Table 20.—Interdistrict movements by tanker and barge of crude oil and petroleum products in 1973, by month

(Thousand barrels)

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	1972 total
Gulf Coast to East Coast, total: [1]														
Crude oil	7,491	5,085	5,044	6,986	5,014	5,485	2,824	3,470	3,590	3,278	4,192	4,155	56,614	106,894
Unfinished oils	2,050	818	1,093	1,491	1,546	862	819	1,405	755	1,160	1,507	1,291	14,797	25,263
Gasoline:														
Motor	20,436	17,523	17,306	15,337	18,372	17,030	19,066	16,397	16,403	15,634	13,566	17,188	204,258	220,966
Aviation	230	208	247	267	499	249	210	383	237	226	185	275	3,216	4,047
Total gasoline	20,666	17,731	17,553	15,604	18,871	17,279	19,276	16,780	16,640	15,860	13,751	17,463	207,474	225,013
Special naphthas	534	598	490	593	727	546	621	655	663	685	451	629	7,192	6,830
Kerosine	2,152	2,115	1,785	568	819	816	939	876	1,591	1,372	717	1,328	15,078	19,982
Distillate fuel oil	14,083	11,153	8,800	5,962	5,908	6,827	6,222	8,328	7,038	7,774	6,119	9,078	97,292	131,099
Residual fuel oil	1,078	2,468	1,243	993	1,931	520	766	963	1,089	1,506	1,370	2,024	15,951	30,389
Jet fuel:														
Naphtha type	527	846	1,154	1,046	1,117	948	788	558	623	251	396	1,226	9,480	12,523
Kerosine type	3,584	3,034	2,811	1,911	2,303	2,226	2,450	2,489	2,450	2,961	2,827	2,508	31,554	32,790
Total jet fuel	4,111	3,880	3,965	2,957	3,420	3,174	3,238	3,047	3,073	3,212	3,223	3,734	41,034	45,313
Lubricating oil	983	929	1,148	946	1,126	975	1,038	1,071	978	955	995	1,198	12,342	11,464
Wax	116	11	33	43	21	28	127	41	70	16	35	32	573	896
Asphalt and road oil	311	243	645	358	680	559	536	657	541	394	489	276	5,689	5,562
Liquefied gases	231	215	151	56	70	70	79	--	95	153	53	131	1,304	1,665
Petrochemical feedstocks	203	206	524	291	177	214	200	84	241	308	315	463	3,226	2,731
Other products	97	87	106	127	186	125	96	177	116	205	211	121	1,654	1,420
Total	54,106	45,539	42,580	36,975	40,496	37,480	36,781	37,554	36,480	36,878	33,428	41,923	480,220	614,521
Gulf Coast to PAD District II:														
Crude oil	899	825	833	876	932	814	1,070	924	690	950	463	974	10,250	18,422
Unfinished oils	9	9	--	--	--	--	--	--	--	--	102	--	120	85
Gasoline:														
Motor	2,735	2,516	2,343	2,553	2,867	2,504	3,062	2,624	2,513	2,536	2,624	3,121	31,998	39,037
Aviation	101	10	34	58	72	83	29	50	47	51	134	63	732	609
Total gasoline	2,836	2,526	2,377	2,611	2,939	2,587	3,091	2,674	2,560	2,587	2,758	3,184	32,730	39,646
Special naphthas	227	238	314	137	256	294	297	303	197	296	263	365	3,187	3,014
Kerosine	119	185	99	123	7	34	31	84	22	87	21	144	956	1,643
Distillate fuel oil	854	1,330	833	1,050	833	1,485	655	1,009	847	681	628	890	11,095	10,952
Residual fuel oil	800	538	782	351	538	837	745	291	621	1,081	976	1,092	8,652	7,407
Jet fuel:														
Naphtha type	--	--	--	--	--	--	--	--	14	--	--	--	14	100
Kerosine type	254	405	309	252	168	180	132	173	145	183	227	184	2,612	4,810
Total jet fuel	254	405	309	252	168	180	132	173	159	183	227	184	2,626	4,910

Lubricating oil	221	298	282	286	199	404	303	513	263	377	287	259	3,692	3,182
Asphalt and road oil	63	44	165	273	276	241	177	538	414	654	330	348	3,523	2,165
Liquefied gases	5	18	--	36	15	101	44	101	15	12	195	112	654	793
Petrochemical feedstocks	88	133	145	190	120	136	178	164	28	173	333	184	1,872	1,908
Other products	131	165	53	25	106	66	77	66	118	81	58	47	993	832
Total	6,506	6,714	6,192	6,210	6,389	7,179	6,800	6,840	5,934	7,162	6,641	7,783	80,350	94,959
Gulf Coast to West Coast:														
Crude oil	--	--	--	--	--	--	--	--	--	--	--	--	--	666
Unfinished oils	--	113	--	--	--	--	--	259	--	--	--	--	372	152
Motor gasoline	--	--	20	--	--	320	44	--	--	291	--	--	675	1,273
Kerosine	2	34	--	--	--	--	--	--	--	--	--	--	36	65
Distillate fuel oil	--	--	--	--	--	--	--	--	365	279	--	43	687	98
Residual fuel oil	--	--	--	--	--	186	--	318	403	354	322	315	1,898	--
Jet fuel:														
Naphtha type	--	--	--	--	--	--	--	--	--	--	--	110	110	134
Kerosine type	--	--	--	--	--	--	--	--	--	--	--	691	691	--
Total jet fuel	--	--	--	--	--	--	--	--	--	--	--	801	801	134
Lubricating oil	155	73	163	88	39	234	152	125	64	113	86	199	1,491	1,586
Petrochemical feedstocks	4	--	--	--	--	--	--	--	--	--	--	--	4	52
Other products	8	16	36	--	--	31	6	--	--	--	--	8	105	7
Total	169	236	219	88	39	771	202	702	832	1,037	408	1,366	6,069	4,033
West Coast to East Coast:														
Special naphthas	--	--	--		--	--	2	--	2	--	--	--	4	--
Residual fuel oil	--	--	--	--	--	--	--	--	--	--	--	--	--	160
Lubricating oil	84	21	28	35	64	46	5	113	47	107	111	29	690	693
Other products	43	--	30	14	42	37	14	17	30	4	--	11	242	82
Total	127	21	58	49	106	83	21	130	79	111	111	40	936	935

[1] Breakdown by region in table 21.

Table 21.—Tanker and barge movements of crude oil and petroleum products from the Gulf Coast to the East Coast, by region in 1973, by month

(Thousand barrels)

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	1972 total
To New England:														
Gasoline:														
Motor	4,706	2,236	4,097	2,929	2,931	2,865	2,745	2,784	2,746	2,424	2,461	2,251	35,175	39,512
Aviation	61	36	8	14	41	46	22	31	49	29	45	95	477	444
Total gasoline	4,767	2,272	4,105	2,943	2,972	2,911	2,767	2,815	2,795	2,453	2,506	2,346	35,652	39,956
Special naphthas	28	17	51	36	96	25	72	22	83	55	48	34	567	447
Kerosine	404	319	207	166	351	72	152	192	181	270	174	336	2,824	3,630
Distillate fuel oil	6,842	4,726	3,943	2,763	2,251	2,617	1,781	2,811	2,784	2,628	2,218	3,236	38,600	52,949
Residual fuel oil	5	1,261	268	24	939	--	292	182	214	478	108	490	4,261	9,135
Jet fuel:														
Naphtha type	64	56	123	254	135	13	139	--	--	--	13	283	1,080	2,010
Kerosine type	279	360	612	291	740	860	451	737	534	769	620	405	6,658	4,308
Total jet fuel	343	416	735	545	875	873	590	737	534	769	633	688	7,738	6,318
Lubricating oil	--	91	71	--	65	21	15	22	42	28	4	73	432	228
Petrochemical feedstocks	24	5	229	5	9	10	--	--	5	10	13	--	310	497
Other products	11	--	7	--	8	--	6	2	10	6	12	--	62	3
Total	12,424	9,107	9,616	6,482	7,566	6,529	5,675	6,783	6,648	6,697	5,716	7,203	90,446	113,163
To Central Atlantic: [1]														
Crude oil	7,443	4,948	5,004	6,913	4,883	5,425	2,763	3,451	3,557	3,278	4,141	4,103	55,909	106,058
Unfinished oils	1,983	818	1,093	1,491	1,546	862	819	1,405	754	1,160	1,333	1,291	14,555	25,222
Gasoline:														
Motor	6,694	4,545	4,066	3,854	4,882	4,563	6,530	4,782	5,406	5,099	4,174	4,283	58,878	69,318
Aviation	32	44	13	68	173	62	90	74	77	105	75	100	913	1,006
Total gasoline	6,726	4,589	4,079	3,922	5,055	4,625	6,620	4,856	5,483	5,204	4,249	4,383	59,791	70,324
Special naphthas	238	347	323	385	400	317	367	424	427	433	244	444	4,349	4,440
Kerosine	864	616	831	220	165	290	301	278	683	804	301	461	5,814	7,515
Distillate fuel oil	4,842	4,244	2,731	1,086	634	1,337	1,894	2,281	1,585	2,738	1,540	2,614	27,526	48,317
Residual fuel oil	635	1,025	286	645	696	485	389	329	530	619	1,046	1,086	7,771	15,010
Jet fuel:														
Naphtha type	--	75	--	198	290	136	13	147	162	--	--	152	1,173	1,490
Kerosine type	1,172	1,125	708	448	441	430	491	789	713	887	953	758	8,915	9,555
Total jet fuel	1,172	1,200	708	646	731	566	504	936	875	887	953	910	10,088	11,045
Lubricating oil	877	712	891	800	827	840	833	902	761	827	771	974	10,015	9,403
Wax	20	11	33	43	21	28	79	41	70	16	35	32	429	864
Asphalt and road oil	--	--	--	--	115	68	68	--	--	27	25	--	303	261
Petrochemical feedstocks	147	122	190	187	148	138	141	34	186	226	266	392	2,177	1,176
Other products	9	42	25	93	110	82	49	143	69	123	161	99	1,005	722
Total	24,956	18,674	16,194	16,431	15,331	15,063	14,827	15,080	14,980	16,342	15,065	16,789	199,732	300,357

To Lower Atlantic:														
Crude oil	48	137	40	73	131	60	61	19	33	--	51	52	705	836
Unfinished oils	67	--	--	--	--	--	--	--	1	--	174	--	242	41
Gasoline:														
Motor	9,036	10,742	9,143	8,554	10,559	9,602	9,791	8,831	8,251	8,111	6,931	10,654	110,205	112,136
Aviation	137	128	226	185	285	141	98	278	111	92	65	80	1,826	2,597
Total gasoline	9,173	10,870	9,369	8,739	10,844	9,743	9,889	9,109	8,362	8,203	6,996	10,734	112,031	114,733
Special naphthas	268	234	116	172	231	204	182	209	153	197	159	151	2,276	1,943
Kerosine	884	1,180	747	182	303	454	486	406	727	298	242	531	6,440	8,837
Distillate fuel oil	2,399	2,183	2,126	2,113	3,023	2,873	2,547	3,236	2,669	2,408	2,361	3,228	31,166	29,833
Residual fuel oil	438	182	689	324	296	35	85	452	345	409	216	448	3,919	6,244
Jet fuel:														
Naphtha type	463	715	1,031	594	692	799	636	411	461	251	383	791	7,227	9,023
Kerosine type	2,133	1,549	1,491	1,172	1,122	936	1,508	963	1,203	1,305	1,254	1,345	15,981	18,927
Total jet fuel	2,596	2,264	2,522	1,766	1,814	1,735	2,144	1,374	1,664	1,556	1,637	2,136	23,208	27,950
Lubricating oil	106	126	186	146	234	114	190	147	175	100	220	151	1,895	1,833
Wax	96	--	--	--	--	--	48	--	--	--	--	--	144	32
Asphalt and road oil	311	243	645	358	565	491	468	657	541	367	464	276	5,386	5,301
Liquefied gases	231	215	151	56	70	70	79	--	95	153	53	131	1,304	1,665
Petrochemical feedstocks	32	79	105	99	20	66	59	50	50	72	36	71	739	1,058
Other products	77	45	74	34	68	43	41	32	37	76	38	22	587	695
Total	16,726	17,758	16,770	14,062	17,599	15,888	16,279	15,691	14,852	13,839	12,647	17,931	190,042	201,001

[1] Includes data formerly shown as barge movements to District I.

Table 22.—Stocks of crude petroleum, natural gas liquids, and refined products in the United States at yearend

(Thousand barrels)

	1969	1970	1971	1972	1973
Crude petroleum:					
At refineries	76,088	80,407	73,115	70,327	76,971
Pipeline and tank farm	172,252	181,580	172,309	162,476	152,533
Producers	16,887	14,380	14,224	13,592	12,974
Total crude petroleum	265,227	276,367	259,648	246,395	242,478
Unfinished oils	97,819	98,989	100,574	94,761	99,154
Natural gasoline, plant condensate, and isopentane	5,704	7,046	6,176	6,075	7,835
Refined products	611,373	635,459	677,549	611,748	658,840
Grand total	980,123	1,017,861	1,043,947	958,979	1,008,307

Table 23.—Stocks of crude petroleum in the United States in 1973, by State or origin and month

(Thousand barrels)

State of origin	Jan. 1	Jan. 31	Feb. 28	Mar. 31	Apr. 30	May 31	June 30	July 31	Aug. 31	Sept. 30	Oct. 31	Nov. 30	Dec. 31
Alabama	763	495	267	449	360	433	265	285	187	450	225	411	228
Alaska	5,271	5,014	3,640	3,810	3,944	2,633	3,897	2,785	2,776	3,287	3,683	4,167	3,564
Arizona	84	78	92	82	84	79	79	85	94	81	72	79	78
Arkansas	663	830	728	781	796	572	820	852	776	545	490	576	494
California	25,380	24,295	24,855	24,812	24,552	24,388	24,229	22,389	21,266	20,069	20,511	18,283	18,809
Colorado	2,910	3,148	3,126	2,721	2,726	2,852	2,896	2,865	3,147	2,958	2,975	2,859	2,939
Florida	670	1,234	1,286	1,065	1,146	1,382	1,408	1,469	983	1,248	1,363	1,588	2,245
Illinois	2,904	3,345	3,251	3,044	3,327	3,374	3,245	3,051	2,846	2,945	3,058	3,003	2,918
Indiana	272	257	175	195	250	510	584	385	452	374	439	422	535
Kansas	5,604	5,233	6,581	5,958	6,145	7,218	6,917	7,781	6,896	6,743	6,936	6,361	6,161
Kentucky	753	453	452	347	373	374	452	386	310	477	502	604	470
Louisiana	30,431	28,481	27,417	29,265	30,667	31,836	30,528	30,136	31,097	29,735	28,926	29,796	28,055
Michigan	505	629	619	768	670	711	629	607	694	714	849	1,088	1,033
Mississippi	3,823	4,674	4,490	4,240	4,289	3,972	3,550	3,260	4,049	3,573	3,444	3,585	3,331
Missouri	--	--	--	--	--	--	--	--	--	--	--	--	1
Montana	3,364	3,529	3,426	3,272	3,556	3,613	3,245	3,262	3,280	3,055	3,124	3,234	2,889
Nebraska	534	741	750	673	657	769	579	551	716	462	562	486	395
Nevada	1	1	1	1	1	1	1	1	1	1	1	--	--
New Mexico	6,042	5,877	6,241	6,709	7,560	7,347	6,561	7,098	6,736	7,262	7,461	7,655	7,102
New York	30	30	30	30	30	30	30	30	30	30	30	30	30
North Dakota	1,469	1,480	1,671	1,626	1,912	1,707	1,611	1,516	1,495	1,616	1,605	1,494	1,417
Ohio	821	903	899	939	950	903	793	795	824	879	947	934	929
Oklahoma	13,144	11,772	12,099	11,416	11,186	12,233	11,627	11,273	11,706	11,773	12,897	13,165	12,254
Pennsylvania	667	716	652	606	579	599	544	662	625	558	554	591	573
Texas	93,120	87,617	86,109	90,105	90,379	95,535	93,107	88,035	91,101	89,950	89,810	91,069	92,999
Utah	2,377	2,782	2,505	3,101	2,840	3,126	2,762	2,635	2,647	2,886	2,878	2,854	3,195
West Virginia	602	563	540	585	606	569	603	609	566	509	524	556	531
Wyoming	14,824	14,416	14,633	15,784	17,462	18,741	18,093	17,064	15,176	14,287	14,617	14,592	13,889
Total domestic crude	217,028	208,593	206,535	212,384	217,047	225,507	219,055	209,867	210,476	206,467	208,483	209,482	207,064
Foreign crude:													
Districts I–IV	18,654	20,945	21,140	18,928	21,662	21,638	20,710	22,973	24,965	23,417	25,777	27,334	24,194
District V	10,713	7,931	7,687	12,819	10,074	10,722	9,092	10,833	12,873	11,392	12,037	13,182	11,220
Total foreign crude	29,367	28,876	28,827	31,747	31,736	32,360	29,802	33,806	37,838	34,809	37,814	40,516	35,414
Total crude stocks	246,395	237,469	235,362	244,131	248,783	257,867	248,857	243,673	248,314	241,276	246,297	249,998	242,478
Pennsylvania grade (included in "Total domestic crude")	1,707	1,810	1,739	1,783	1,793	1,796	1,687	1,856	1,754	1,647	1,698	1,843	1,767

Table 24.—Stocks of crude petroleum in the United States in 1973, by State and month

(Thousand barrels)

State	Jan. 1	Jan. 31	Feb. 28	Mar. 31	Apr. 30	May 31	June 30	July 31	Aug. 31	Sept. 30	Oct. 31	Nov. 30	Dec. 31
Alabama	854	682	879	766	1,042	885	536	639	563	536	549	587	906
Alaska	1,020	1,432	805	714	1,198	976	720	657	705	912	868	862	434
Arizona	444	445	447	447	444	445	448	446	450	447	449	450	452
Arkansas	999	1,355	1,086	1,309	1,317	1,034	1,343	1,372	1,295	1,057	1,014	1,116	1,038
California, Nevada, Oregon, Washington	40,133	35,596	35,047	40,384	37,427	36,938	36,490	35,100	36,052	33,945	35,615	34,642	32,645
Colorado	1,863	1,843	1,812	1,825	1,723	1,853	1,861	1,852	1,838	1,610	1,831	1,892	1,861
Florida, Georgia, South Carolina, Virginia	1,377	1,320	825	1,082	1,304	1,240	1,536	1,431	1,062	1,599	1,631	1,318	1,617
Hawaii	717	892	1,015	1,215	714	818	783	999	1,094	659	644	1,028	1,468
Illinois	16,084	15,346	14,501	16,223	16,675	17,596	16,963	16,007	15,732	17,216	16,273	15,617	14,734
Indiana	3,427	3,494	3,623	3,358	3,489	3,673	3,559	3,264	3,242	3,225	3,103	3,165	3,361
Iowa, Missouri	6,188	6,406	6,110	6,172	6,378	6,670	6,151	6,369	5,904	5,940	6,592	6,077	6,041
Kansas	9,228	9,012	9,987	10,114	10,179	11,484	11,200	11,715	11,139	10,902	11,253	10,209	9,800
Kentucky, Tennessee	4,189	4,422	4,175	4,056	3,910	3,664	3,562	3,306	3,808	3,787	4,028	4,238	3,946
Louisiana	18,893	21,592	17,944	18,809	18,941	20,521	18,966	19,461	20,714	20,450	20,129	21,536	18,702
Maryland	262	206	237	228	249	400	421	354	304	311	257	300	277
Massachusetts, Delaware, Rhode Island	610	1,457	798	1,088	611	515	541	836	1,557	1,217	989	754	484
Michigan	2,734	3,506	2,486	1,868	1,998	1,866	1,710	1,690	1,859	2,026	2,404	2,189	2,325
Minnesota, Wisconsin	2,127	2,311	2,543	2,869	2,806	2,233	1,871	2,078	1,752	1,984	2,394	2,572	1,978
Mississippi	5,708	6,176	5,552	5,244	5,387	4,899	4,839	4,680	4,998	5,042	4,716	4,749	4,898
Montana	3,032	3,042	2,659	2,325	2,781	2,693	2,485	2,811	2,499	2,446	2,471	2,647	2,624
Nebraska	1,434	1,494	1,528	1,700	1,641	1,651	1,474	1,477	1,575	1,433	1,524	1,520	1,570
New Jersey	4,503	5,269	5,119	4,943	6,096	6,062	6,369	4,941	5,357	5,011	5,127	5,679	6,527
New Mexico	3,636	3,674	3,453	3,636	3,683	3,629	3,841	3,667	3,729	3,838	3,844	4,038	3,773
New York	386	477	500	374	361	455	471	405	439	329	471	419	385
North Dakota	1,288	1,294	1,493	1,322	1,648	1,478	1,373	1,317	1,331	1,445	1,392	1,262	1,172
Ohio	5,811	5,334	5,164	4,809	6,234	7,440	6,692	5,693	5,940	5,755	6,575	6,283	5,573
Oklahoma	14,984	13,737	14,405	14,453	14,982	15,842	15,006	15,138	16,238	16,051	17,791	18,671	16,925
Pennsylvania	6,545	7,014	7,400	6,092	7,427	7,030	6,465	6,736	7,540	5,906	8,165	8,410	8,319
Texas	78,331	69,385	74,468	76,763	76,737	81,642	79,070	78,600	79,731	77,096	75,241	78,784	79,388
Utah	1,174	1,194	1,181	1,234	1,362	1,288	1,271	1,295	1,108	1,038	1,171	1,153	1,130
West Virginia	627	583	568	588	594	554	563	601	563	601	581	559	509
Wyoming	7,787	7,479	7,552	8,121	9,445	10,393	10,277	8,736	8,196	7,462	7,205	7,272	7,616
Total	246,395	237,469	235,362	244,131	248,783	257,867	248,857	243,673	248,314	241,276	246,297	249,998	242,478

Table 25.—Stocks of crude petroleum in the United States in 1973, by classification and State and month

(Thousand barrels)

Classification and State	Jan. 1	Jan. 31	Feb. 28	Mar. 31	Apr. 30	May 31	June 30	July 31	Aug. 31	Sept. 30	Oct. 31	Nov. 30	Dec. 31
At refineries:													
Alabama	214	146	183	177	312	295	172	186	185	220	221	185	134
Alaska	126	147	103	85	176	105	177	87	67	104	82	102	109
Arkansas	122	117	105	132	126	107	123	108	98	89	105	89	87
California, Arizona, Nevada, Oregon, Washington	20,475	17,932	17,509	23,362	20,235	20,153	19,041	19,735	22,102	20,294	20,981	23,016	20,099
Colorado	533	524	490	495	210	305	256	301	333	163	286	282	274
Florida, Georgia, South Carolina, Virginia	1,044	920	661	951	1,056	1,025	1,091	958	857	1,282	1,359	836	1,237
Hawaii	717	892	1,015	1,215	714	818	783	999	1,094	659	644	1,028	1,468
Illinois	3,550	3,468	3,818	3,436	4,418	4,291	4,281	4,332	4,038	4,298	4,626	4,386	4,087
Indiana	1,151	1,076	1,320	1,235	1,183	1,225	1,231	1,212	1,199	1,188	1,125	1,147	1,299
Kansas	1,397	1,227	1,255	1,328	1,469	1,892	1,673	1,767	1,802	2,066	2,086	1,822	1,600
Kentucky, Tennessee	1,108	1,500	1,352	1,373	1,229	1,358	1,162	948	1,045	1,024	1,295	1,436	1,247
Louisiana	6,231	5,143	5,657	6,025	5,976	6,832	6,472	6,584	7,361	7,330	7,086	7,722	5,546
Maryland	262	206	237	228	249	400	421	354	304	311	257	300	277
Massachusetts, Delaware, Rhode Island	610	1,457	798	1,088	611	515	541	836	1,557	1,217	989	754	484
Michigan	731	776	799	760	749	562	590	482	699	775	880	831	868
Minnesota, Wisconsin	1,026	1,244	1,334	1,475	1,484	1,272	1,070	1,216	1,021	1,301	1,362	1,345	1,180
Mississippi	848	807	622	826	886	754	847	849	959	962	899	839	599
Missouri	298	306	307	315	330	323	305	324	315	310	314	303	311
Montana	812	763	683	631	880	801	711	1,067	776	601	689	710	682
Nebraska	28	16	15	20	19	23	20	14	19	18	16	24	16
New Jersey	4,503	5,269	5,119	4,943	6,096	6,062	6,369	4,941	5,357	5,011	5,127	5,679	6,527
New Mexico	154	185	168	160	234	230	199	161	155	195	180	201	207
New York	356	447	470	344	331	425	441	375	409	299	441	389	355
North Dakota	234	192	243	276	584	461	373	306	314	386	353	259	192
Ohio	1,793	1,646	1,564	1,773	2,195	2,402	2,049	2,018	2,051	1,998	1,772	1,945	1,777
Oklahoma	1,356	1,058	1,354	1,536	1,425	1,316	1,377	1,252	1,356	1,432	1,694	1,705	1,303
Pennsylvania	5,721	6,151	6,604	5,340	6,705	6,270	5,545	5,838	6,551	5,106	7,339	7,467	7,354
Texas	13,552	14,024	14,561	15,709	15,770	16,955	15,591	17,886	17,350	16,743	14,676	17,768	16,314
Utah	507	512	481	475	570	450	506	575	501	535	489	488	493
West Virginia	133	146	138	178	158	128	121	114	124	151	126	113	118
Wyoming	735	717	593	549	667	719	685	726	639	680	694	850	727
Total at refineries	70,327	69,014	69,558	76,440	77,047	78,474	74,223	76,551	80,638	76,748	78,193	84,021	76,971

Pipeline and tank-farm stocks:													
Alabama	546	476	637	536	675	536	310	398	325	260	274	349	716
Alaska	839	1,230	641	569	955	808	494	498	571	736	714	684	270
Arkansas	779	1,140	898	1,094	1,108	844	1,137	1,188	1,121	892	844	962	886
California, Arizona	18,433	16,564	16,321	15,914	16,241	15,935	16,516	14,397	13,112	12,637	13,624	10,523	11,689
Colorado	1,130	1,114	1,123	1,126	1,259	1,301	1,409	1,355	1,309	1,238	1,345	1,409	1,374
Florida	293	346	115	80	203	181	409	431	167	275	231	432	339
Illinois	12,269	11,620	10,426	12,527	11,990	13,047	12,423	11,416	11,439	12,655	11,388	10,978	10,391
Indiana	2,242	2,384	2,269	2,089	2,272	2,408	2,295	2,019	2,010	2,004	1,974	1,985	2,029
Iowa, Missouri	5,890	6,100	5,803	5,857	6,048	6,347	5,846	6,045	5,589	5,630	6,278	5,774	5,729
Kansas	7,575	7,535	8,481	8,532	8,457	9,351	9,291	9,708	9,107	8,597	8,941	8,161	7,970
Kentucky, Tennessee	3,030	2,871	2,772	2,632	2,630	2,255	2,349	2,307	2,712	2,712	2,682	2,751	2,648
Louisiana	10,522	14,350	10,126	10,633	10,746	11,456	10,302	10,736	11,242	10,972	10,886	11,349	10,597
Michigan	1,907	2,634	1,591	1,012	1,158	1,213	1,029	1,117	1,069	1,149	1,430	1,264	1,357
Minnesota, Wisconsin	1,101	1,067	1,209	1,394	1,322	961	801	862	731	683	1,032	1,227	798
Mississippi	4,549	5,052	4,603	4,084	4,184	3,845	3,685	3,616	3,824	3,855	3,610	3,703	4,092
Montana	1,899	1,968	1,654	1,375	1,569	1,573	1,460	1,429	1,417	1,534	1,478	1,633	1,629
Nebraska	1,308	1,380	1,415	1,582	1,524	1,530	1,356	1,365	1,458	1,317	1,410	1,398	1,456
New Mexico	2,494	2,432	2,316	2,500	2,488	2,447	2,701	2,567	2,633	2,710	2,738	2,978	2,716
North Dakota	990	1,032	1,182	955	980	941	926	940	941	983	977	945	919
Ohio	3,943	3,613	3,525	2,961	3,964	4,963	4,568	3,600	3,814	3,682	4,728	4,263	3,721
Oklahoma	12,643	11,672	12,062	11,919	12,590	13,573	12,665	12,922	13,935	13,660	15,149	16,095	14,746
Pennsylvania	695	734	681	637	607	645	805	771	862	673	699	816	819
Texas	59,992	50,621	55,186	56,292	56,167	60,006	58,861	56,088	57,831	55,730	56,016	56,522	58,476
Utah	546	564	580	644	667	719	633	604	484	381	564	542	517
West Virginia	329	272	265	245	271	261	277	322	274	285	290	281	226
Wyoming	6,532	6,271	6,454	7,067	8,261	9,157	9,075	7,498	7,045	6,282	6,025	5,956	6,423
Total	162,476	155,042	152,335	154,256	158,336	166,303	161,623	154,199	155,022	151,532	155,327	152,980	152,533
Lease stocks	13,592	13,413	13,469	13,435	13,400	13,090	13,011	12,923	12,654	12,996	12,777	12,997	12,974
Total stocks 1973	246,395	237,469	235,362	244,131	248,783	257,867	248,857	243,673	248,314	241,276	246,297	249,998	242,478
1972	259,648	251,012	252,945	258,902	266,636	279,490	271,381	265,843	257,976	250,802	253,748	251,306	246,395

Table 26.—Value of crude petroleum at wells in the United States, by State

State	1972		1973	
	Total value at wells (thousand dollars)	Average value per barrel	Total value at wells (thousand dollars)	Average value per barrel
Alabama	30,466	$3,07	41,772	$3.58
Alaska	235,444	3.23	261,877	3.62
Arizona	3,226	3.25	3,103	3.86
Arkansas	58,335	3.15	70,618	3.92
California	940,430	2.71	1,045,193	3.11
Colorado	109,171	3.41	155,507	4.25
Florida	53,732	3.18	150,070	4.59
Illinois	121,013	3.47	132,490	4.32
Indiana	20,964	3.42	20,823	3.92
Kansas	259,578	3.52	281,465	4.25
Kentucky	32,599	3.36	34,515	3.97
Louisiana:				
Gulf Coast	3,044,933	3.59	3,170,847	4.00
Northern	156,726	3.54	156,855	3.94
Total Louisiana	3,201,659	3.59	3,327,702	4.00
Michigan	41,556	3.20	59,413	4.07
Mississippi	192,465	3.15	213,747	3.81
Montana	103,924	3.07	115,423	3.33
Nebraska	29,423	3.38	28,035	3.87
New Mexico:				
Southeastern	349,586	3.43	383,740	4.11
Northwestern	27,192	3.16	30,301	4.00
Total New Mexico	376,778	3.41	414,041	4.10
New York	4,897	4.81	5,412	5.60
North Dakota	67,647	3.28	78,916	3.90
Ohio	35,179	3.76	44,690	5.08
Oklahoma	709,033	3.41	723,273	3.78
Pennsylvania	16,414	4.77	18,440	5.62
South Dakota	574	2.62	988	3.59
Texas:				
Gulf Coast	971,022	3.73	1,041,037	4.11
East Texas Field	254,051	3.52	300,775	3.98
West Texas	2,203,363	3.41	2,639,280	3.95
Panhandle	83,773	3.43	87,859	3.94
Rest of State	1,023,868	3.43	1,088,672	3.94
Total Texas	4,536,077	3.48	5,157,623	3.98
Utah	80,773	3.04	117,743	3.61
West Virginia	12,047	4.50	11,965	5.02
Wyoming	432,071	3.09	541,820	3.82
Other States [1]	1,035	2.89	1,241	3.48
Total United States	11,706,510	3.39	13,057,905	3.89

[1] Missouri, Nevada, Tennessee, and Virginia (for 1972 only).

Table 27.—Posted price per barrel of petroleum at wells in the United States in 1972 and in 1973, by grade

(Dollars)

Grade	1972 price per barrel	1973 Date of price change and price per barrel							
		Jan. 1	Mar. 15	Mar. 31	Apr. 15	May 1	June 9	Aug. 20	Dec. 19
Pennsylvania grade:									
Bradford and Allegheny districts	4.88	5.18	--	--	--	--	--	5.83	6.83
Southwest Pennsylvania	4.17	4.77	--	--	--	--	--	5.12	6.12
Corning grade	3.42	3.52	--	--	--	--	--	4.17	5.17
Western Kentucky	3.60	3.60	--	3.85	--	--	--	4.20	5.20
Indiana–Illinois	3.60	3.60	--	3.85	--	--	--	4.20	5.20
Coldwater, Michigan	3.35	3.37	--	3.64	--	--	--	3.98	5.00
Oklahoma–Kansas:									
34°–34.9° API	3.42	3.42	3.73	--	--	--	--	4.11	5.11
36°–36.9° API	3.50	3.50	3.77	--	--	--	--	4.15	5.15
Texas, Panhandle (Carson, Gray, Hutchinson and Wheeler Counties) 35°–35.9° API	3.41	3.41	3.75	--	--	--	--	4.10	5.10
West Texas 30°–30.9° API (sweet)	3.36	3.36	--	--	3.61	--	--	4.11	5.11
Lea County, New Mexico, 30°–30.9° API (sour)	3.25	3.25	--	3.50	--	--	--	4.00	5.00
South Texas, Mirando, 24°–24.9° API	3.65	3.65	--	--	--	3.95	--	4.30	5.30
East Texas	3.60	3.60	--	--	3.85	--	--	4.20	5.20
Conroe, Texas	3.70	3.70	--	--	--	3.95	--	4.30	5.30
Texas:									
30°–30.9° API	3.45	3.45	--	--	--	3.70	--	4.05	5.05
20°–20.9° API	3.35	3.35	--	--	--	3.60	--	3.95	4.95
Louisiana, 30°–30.9° API	3.55	3.55	--	--	3.80	--	--	4.15	5.15
Caddo-Pine Island, Louisiana, 36°–36.9° API	3.44	3.44	--	3.69	--	--	--	4.04	5.04
Magnolia Smackover Limestone, Arkansas, 31°–31.9° API	3.07	3.07	--	3.49	--	--	3.84	--	4.84
Elk Basin, Wyoming (including Montana) 30°–30.9° API	3.16	3.16	--	3.46	--	--	--	3.86	4.86
California:									
Coalinga, 32°–32.9° API	3.41	3.41	--	--	--	--	--	3.76	4.76
Kettleman Hills, 37°–37.9° API	3.66	3.66	--	--	--	--	--	4.01	5.01
Midway Sunset, 19°–19.9° API	2.68	2.68	--	--	--	--	--	3.03	4.03
Wilmington, 24°–24.9° API	3.03	3.03	--	--	--	--	--	3.38	4.38

Source: Platt's Oil Price Handbook.

Table 28.—Wholesale price index, crude petroleum

(1967=100) [1]

Month	1969	1970	1971	1972	1973
January	99.7	106.0	113.2	113.2	114.7
February	99.9	106.0	113.2	113.2	114.7
March	103.7	106.0	113.2	113.2	114.9
April	104.8	106.0	113.2	113.2	117.1
May	104.7	106.0	113.2	113.2	122.0
June	104.5	106.0	113.2	113.2	125.3
July	104.5	104.8	113.2	113.2	125.8
August	104.5	104.8	113.2	114.7	125.8
September	104.5	104.8	113.2	114.7	133.3
October	104.5	104.8	113.2	114.7	133.3
November	104.5	104.8	113.2	114.7	139.3
December	104.5	113.2	113.2	114.7	146.2
Average	103.7	106.1	113.2	113.8	126.0

[1] Reference base prior to 1970 (1957–59=100).

Source: Bureau of Labor Statistics, U.S. Department of Labor.

Table 29.—Average monthly price of petroleum products in the United States, 1972–73

Monthly average and grade	Year	January	February	March	April	May	June	July	August	September	October	November	December	Average for year
Gasoline 92 octane (cents per gallon):														
At refineries in Oklahoma	1972	12.73	12.63	12.67	12.88	12.88	12.88	12.88	12.88	12.88	12.88	12.88	12.88	12.83
	1973	12.96	13.18	13.38	13.71	13.88	14.75	14.75	14.75	15.25	16.50	18.34	20.43	15.16
Tank wagon prices to dealers at 55 cities on first of month	1972	18.04	17.92	16.96	17.21	16.52	17.15	17.71	17.31	18.92	18.47	18.13	18.30	17.72
	1973	18.46	18.09	18.75	19.02	19.21	19.22	19.22	19.11	19.13	20.17	20.90	22.53	19.48
At service station (including all taxes)	1972	36.53	37.05	34.79	35.34	34.41	35.20	35.82	35.29	37.95	37.29	36.87	37.02	36.13
	1973	37.16	36.74	37.87	38.25	38.42	38.71	38.76	38.78	38.71	39.66	40.53	42.26	38.82
Kerosine (cents per gallon):														
No. 1 range at Chicago district	1972	12.00	11.84	11.70	11.70	11.70	11.74	11.75	11.75	11.75	12.08	12.13	12.13	11.86
	1973	12.27	12.98	13.49	14.60	15.13	15.53	15.00	15.01	16.88	17.88	20.16	22.77	15.98
No. 1 fuel oil at Oklahoma	1972	10.25	10.25	10.25	10.25	10.25	10.25	10.25	10.25	10.25	10.26	10.50	10.50	10.29
	1973	10.53	11.34	11.38	11.78	12.38	12.69	12.75	12.75	13.19	14.19	15.49	18.40	13.07
Kerosine (or No. 1 fuel oil) at New York Harbor	1972	12.23	12.23	12.23	12.23	12.23	12.23	12.23	12.23	12.23	12.23	12.23	12.23	12.23
	1973	13.09	13.75	13.75	13.75	13.75	13.75	13.75	13.75	13.75	14.65	16.23	17.30	14.27
Kerosine (or No. 1 fuel oil) at Tampa	1972	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50	12.50
	1973	12.69	13.25	13.25	13.25	13.25	13.25	13.25	13.25	13.25	13.25	15.82	17.29	13.75
Distillate and diesel fuel oil (cents per gallon):														
No. 2 fuel oil at refineries, Oklahoma	1972	9.50	9.50	9.50	9.50	9.50	9.50	9.50	9.50	9.50	9.50	9.75	9.75	9.54
	1973	9.95	10.48	10.50	10.90	11.50	11.81	11.88	11.88	12.31	13.31	14.50	17.40	12.20
No. 2 fuel oil at New York Harbor	1972	11.85	11.85	11.85	11.85	11.85	11.85	11.85	11.85	11.85	11.85	11.85	11.85	11.85
	1973	12.09	12.75	12.75	13.00	13.38	14.07	14.28	14.38	15.13	16.93	18.62	22.70	15.01
Diesel oil, shore plants, New York	1972	12.15	12.15	12.15	12.15	12.15	12.15	12.15	12.15	12.15	12.44	12.45	12.45	12.22
	1973	([1])	([1])	([1])	([1])	([1])	([1])	([1])	([1])	([1])	([1])	([1])	([1])	([1])
Light diesel oil for ships (dollars per barrel):														
New York	1972	5.08	5.16	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.17	5.32	5.32	5.18
	1973	5.32	5.32	5.32	5.50	5.67	5.76	6.26	6.47	6.90	7.47	9.87	10.67	6.70
New Orleans	1972	5.10	4.95	4.95	4.89	4.89	4.89	4.89	4.89	4.89	4.89	5.04	5.04	4.94
	1973	5.04	5.04	5.04	5.34	5.67	5.76	6.26	6.47	6.90	7.47	10.16	10.88	6.67
San Pedro	1972	5.95	6.06	6.06	6.06	6.06	6.06	6.06	6.06	6.06	6.06	6.06	6.06	6.05
	1973	([1])	([1])	([1])	([1])	([1])	([1])	([1])	([1])	([1])	([1])	([1])	([1])	([1])
San Francisco Marine Diesel	1972	6.16	6.27	6.27	6.27	6.27	6.27	6.27	6.27	6.27	6.27	6.27	6.27	6.26
	1973	6.27	6.27	6.27	6.27	6.27	6.27	7.28	7.61	7.68	8.12	9.73	10.13	7.35
Residual fuel oil (dollars per barrel):														
No. 6 fuel at refineries, Oklahoma	1972	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60
	1973	2.60	2.60	2.60	2.72	2.73	2.73	2.73	2.73	2.73	3.13	3.34	4.28	2.91
No. 5 fuel oil at New York Harbor	1972	4.35	4.34	4.05	4.05	4.05	4.05	4.05	4.05	4.05	4.05	4.05	4.10	4.10
	1973	4.35	4.35	4.45	4.64	4.64	4.64	4.64	([2])	([2])	([2])	([2])	([2])	[2] 4.53
Bunker "C" for ships:														
New York	1972	3.41	3.45	3.45	3.45	3.45	3.45	3.45	3.45	3.45	3.45	3.45	3.45	3.45
	1973	3.48	3.48	3.48	3.55	3.60	3.60	3.60	3.60	3.60	4.53	5.23	5.42	3.93
New Orleans	1972	3.42	3.45	3.45	3.45	3.45	3.45	3.45	3.45	3.45	3.45	3.45	3.45	3.45
	1973	3.48	3.48	3.48	3.55	3.60	3.60	3.60	3.60	3.60	4.52	5.73	6.10	4.03
San Pedro	1972	3.50	3.64	3.64	3.64	3.64	3.64	3.64	3.64	3.64	3.64	3.64	3.64	3.63
	1973	([1])	([1])	([1])	([1])	([1])	([1])	([1])	([1])	([1])	([1])	([1])	([1])	([1])
San Francisco	1972	3.55	3.69	3.69	3.69	3.69	3.69	3.69	3.69	3.69	3.69	3.69	3.69	3.68
	1973	3.69	3.69	3.69	3.80	3.87	3.87	4.27	4.60	5.06	5.40	6.72	7.21	4.65

Lubricating oil (cents per gallon):														
East Coast:														
200 viscosity at 100, 0–10 pour test, 95 V.I	1972	23.50	23.50	23.50	23.50	23.50	23.50	23.50	23.50	23.50	23.50	24.24	24.69	23.66
	1973	27.25	27.25	27.25	27.25	27.25	27.25	27.25	27.94	28.50	31.00	31.73	33.00	28.58
500 viscosity at 100, 0–10 pour test, 95 V.I	1972	25.50	25.50	25.50	25.50	25.50	25.50	25.50	25.50	25.50	25.50	26.23	26.69	25.66
	1973	25.75	25.75	25.75	25.75	25.75	25.75	26.25	26.31	26.50	29.00	29.73	31.00	26.94
South Texas:														
500 viscosity No. 2½–3½ color	1972	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
	1973	19.75	19.75	19.75	19.75	19.75	19.75	19.75	20.52	22.52	24.06	25.00	25.00	21.28
Liquefied petroleum gas (propane) (cents per gallon):														
New York Harbor [3]	1972	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.50	8.95	9.18	9.18	9.18	8.71
	1973	9.18	9.18	9.18	9.36	9.48	10.42	10.89	10.89	12.14	11.69	12.37	13.38	10.68
Oklahoma	1972	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.25	5.60	5.67	5.67	5.67	5.38
	1973	5.67	5.90	6.46	6.93	8.30	9.28	9.50	9.50	11.40	13.83	13.83	13.86	9.54
Baton Rouge	1972	5.73	5.73	5.73	5.73	5.73	5.73	5.73	5.73	6.12	6.21	6.21	6.21	5.88
	1973	6.21	6.40	6.91	7.26	8.49	9.16	9.25	9.25	10.07	11.50	11.85	13.28	9.13

[1] Eliminated.
[2] Partial average.
[3] Philadelphia combined with New York Harbor in 1972.

Table 30.—Salient statistics of the major refined petroleum products in the United States

(Thousand barrels)

Product	1970	1971	1972	1973 p
Isopentane:				
Production	3,865	5,565	7,251	5,828
Stocks at plants	7	31	99	32
Used at refineries	3,868	5,541	7,183	5,895
Natural gasoline:				
Production	161,274	159,732	156,450	155,880
Stocks end of year:				
At plants	4,316	3,647	3,285	5,043
At refineries	1,765	1,485	1,418	1,085
Total stocks	6,081	5,132	4,703	6,128
Used at refineries	160,108	160,681	156,879	154,455
Plant condensate:				
Production	31,972	25,754	22,022	19,838
Stocks end of year:				
At plants	507	594	763	739
At refineries	451	419	510	936
Total stocks	958	1,013	1,273	1,675
Imports	2,258	13,321	31,428	37,475
Used at refineries	34,051	39,020	53,190	56,911
Finished gasoline:				
Production:				
At refineries	2,099,911	2,197,550	2,315,768	2,398,831
At gas processing plants	5,347	5,023	4,182	3,029
Total gasoline production	2,105,258	2,202,573	2,319,950	2,401,860
Stocks end of year:				
At refineries	214,150	223,544	217,025	213,334
At plants	198	227	124	83
Total stocks	214,348	223,771	217,149	213,417
Imports	24,320	21,658	24,787	48,106
Exports	1,370	1,649	656	1,666
Domestic demand	2,131,252	2,213,159	2,350,703	2,452,032
Motor gasoline:				
Production:				
At refineries	2,080,199	2,179,093	2,298,775	2,382,418
At gas processing plants	5,347	5,023	4,182	3,029
Total motor gasoline production	2,085,546	2,184,116	2,302,957	2,385,447
Stocks end of year:				
At refineries	209,057	219,125	212,770	209,395
At plants	198	227	124	83
Total motor gasoline stocks	209,255	219,352	212,894	209,478
Imports	24,320	21,658	24,787	48,106
Exports	461	410	424	1,468
Domestic demand	2,111,349	2,195,267	2,333,778	2,435,501
Aviation gasoline:				
Production	19,712	18,457	16,993	16,413
Stocks end of year	5,093	4,419	4,255	3,939
Exports	909	1,239	232	198
Domestic demand	19,903	17,892	16,925	16,531
Jet fuel:				
Production	301,913	304,674	310,029	313,689
Stocks end of year	27,610	27,737	25,493	28,544
Imports	52,696	65,712	71,174	74,285
Exports	2,094	1,536	957	1,568
Domestic demand	352,978	368,723	382,490	383,355
Naphtha type:				
Production:				
At refineries	84,060	85,317	76,565	65,997
At gas processing plants	21	9	--	--
Total production	84,081	85,326	76,565	65,997
Stocks end of year:				
At refineries	6,618	6,988	6,147	5,599
At plants	3	2	--	--
Total stocks	6,621	6,990	6,147	5,599
Imports	7,005	11,092	11,998	13,315
Exports	2,094	1,317	911	640
Domestic demand	90,927	94,732	88,495	79,220
Kerosine type:				
Production	217,832	219,348	233,464	247,692
Stocks end of year	20,989	20,747	19,346	22,945
Imports	45,691	54,620	59,176	60,970
Exports	--	219	46	928
Domestic demand	262,051	273,991	293,995	304,135

See footnotes at end of table.

Table 30.—Salient statistics of the major refined petroleum products in the United States—Continued

(Thousand barrels)

Product	1970	1971	1972	1973 p
Ethane (including ethylene):				
Production:				
At gas processing plants	73,434	80,524	100,691	108,220
At refineries	9,460	9,266	9,197	9,194
Total production	82,894	89,790	109,888	117,414
Stocks end of year:				
At plants	1,319	3,365	7,052	5,023
At refineries	--	--	--	--
Total stocks	1,319	3,365	[1] 7,052	[1] 5,023
Domestic demand:				
Plant ethane	74,297	78,478	97,004	110,249
Refinery ethane and/or ethylene	9,460	9,266	9,197	9,194
Total domestic demand	83,757	87,744	106,201	119,443
Liquefied gases:				
Production:				
At gas processing plants (LPG)	326,177	337,110	344,045	338,813
At refineries (LRG):				
For fuel use	80,870	88,648	84,514	89,570
For chemical use	35,657	32,304	36,668	38,062
Total production at refineries	116,527	120,952	121,182	127,632
Total production	442,704	458,062	465,227	466,445
Stocks end of year:				
LPG stocks:				
At plants	59,276	80,294	67,807	83,086
At refineries	794	3,693	3,077	2,813
Total LPG stocks	60,070	83,987	70,884	85,899
LRG stocks:				
For fuel use	5,433	6,992	7,487	7,403
For chemical use	221	369	294	316
Total LRG stocks	5,654	7,361	7,781	7,719
Total stocks	65,724	91,348	[1] 78,665	[1] 93,618
Imports	18,921	25,655	32,401	47,801
Exports	9,955	9,390	11,469	9,956
LPG used at refineries	80,307	79,695	85,193	80,221
Domestic demand:				
LPG for fuel and chemical use	251,051	249,767	292,887	281,422
LRG for fuel use	80,219	87,089	84,019	89,654
LRG for chemical use	31,789	32,152	36,743	38,040
Total domestic demand	363,059	369,008	413,649	409,116
Propane (including propylene):				
Production:				
At gas processing plants	202,494	212,143	218,039	212,886
At refineries:				
For fuel use	63,409	71,934	69,038	73,531
For chemical use	20,090	21,512	25,024	25,329
Total production at refineries	83,499	93,446	94,062	98,860
Total production	285,993	305,589	312,101	311,746
Stocks end of year:				
Plant propane stocks:				
At plants	38,791	56,779	48,219	59,704
At refineries	84	769	190	357
Total plant propane stocks	38,875	57,548	48,409	60,061
Refinery propane and/or propylene stocks:				
For fuel use	4,301	5,050	4,959	4,399
For chemical use	146	263	193	187
Total refinery propane and/or propylene stocks	4,447	5,313	5,152	4,586
Total stocks	43,322	62,861	53,561	64,647
Imports	9,467	11,060	15,851	25,614
Exports	2,165	4,665	6,502	5,501
Plant propane used at refineries	1,530	3,273	3,934	2,755
Domestic demand:				
Plant propane	200,770	197,138	232,593	218,592

See footnotes at end of table.

Table 30.—Salient statistics of the major refined petroleum products in the United States—Continued

(Thousand barrels)

Product	1970	1971	1972	1973 p
Liquefied gases—Continued				
Propane (including propylene)—Continued				
Domestic demand—Continued				
Refinery propane and/or propylene:				
For fuel use	62,191	71,185	69,129	74,091
For chemical use	20,159	21,395	25,094	25,335
Total refinery propane and/or propylene domestic demand	82,350	92,580	94,223	99,426
Total domestic demand	283,120	289,718	326,816	318,018
Butane (including butylene):				
Production:				
At gas processing plants	87,253	88,544	88,924	88,766
At refineries:				
For fuel use	13,514	13,765	12,940	13,036
For chemical use	8,693	5,886	5,673	6,666
Total production at refineries	22,207	19,651	18,613	19,702
Total production	109,460	108,195	107,537	108,468
Stocks end of year:				
Plant butane stocks:				
At plants	14,397	13,571	10,389	15,289
At refineries	414	1,614	1,425	1,369
Total plant butane stocks	14,811	15,185	11,814	16,658
Refinery butane and/or butylene stocks:				
For fuel use	912	1,448	2,161	2,471
For chemical use	35	11	15	16
Total refinery butane and/or butylene stocks	947	1,459	2,176	2,487
Total stocks	15,758	16,644	13,990	19,145
Imports	9,454	14,049	16,550	22,187
Exports	1,655	4,725	4,967	4,455
Plant butane used at refineries	43,758	46,061	44,512	39,327
Domestic demand:				
Plant butane	50,083	51,433	59,366	62,327
Refinery butane and/or butylene:				
For fuel use	14,050	13,229	12,227	12,726
For chemical use	8,694	5,910	5,669	6,665
Total refinery butane and/or butylene	22,744	19,139	17,896	19,391
Total domestic demand	72,827	70,572	77,262	81,718
Butane-propane mixture:				
Production:				
At gas processing plants	5,677	4,173	3,535	3,509
At refineries:				
For fuel use	3,947	2,949	2,536	3,003
For chemical use	5,353	3,029	3,892	3,491
Total production at refineries	9,300	5,978	6,428	6,494
Total production	14,977	10,151	9,963	10,003
Stocks end of year:				
Plant butane-propane mixture:				
At plants	733	815	944	826
At refineries	35	38	31	128
Total plant butane-propane mixture stocks	768	853	975	954
Refinery butane-propane mixture:				
For fuel use	220	494	367	533
For chemical use	--	3	2	3
Total refinery butane-propane mixture stocks	220	497	369	536
Total stocks	988	1,350	1,344	1,490
Exports	6,135	--	--	--
Plant butane-propane mixture used at refineries	2,822	2,896	2,485	3,027
Domestic demand:				
Plant butane-propane mixture	198	1,192	928	503

See footnotes at end of table.

Table 30.—Salient statistics of the major refined petroleum products in the United States—Continued

(Thousand barrels)

Product	1970	1971	1972	1973 p
Liquefied gases—Continued				
Butane-propane mixture—Continued				
Domestic demand—Continued				
Refinery butane-propane mixture:				
For fuel use	3,978	2,675	2,663	2,837
For chemical use	1,438	3,026	3,893	3,490
Total refinery butane-propane mixture	5,416	5,701	6,556	6,327
Total domestic demand	5,614	6,893	7,484	6,830
Isobutane:				
Production:				
At gas processing plants	30,753	32,250	33,547	33,652
At refineries	1,521	1,877	2,079	2,576
Total production	32,274	34,127	35,626	36,228
Stocks end of year:				
Plant isobutane:				
At plants	5,355	9,129	8,255	7,267
At refineries	261	1,272	1,431	959
Total plant isobutane stocks	5,616	10,401	9,686	8,226
Refinery isobutane	40	92	84	110
Total stocks	5,656	10,493	9,770	8,336
Plant isobutane used at refineries	32,197	27,465	34,262	35,112
Domestic demand:				
Refinery isobutane for chemical use	1,498	1,825	2,087	2,550
Kerosine (including range oil):				
Production:				
At refineries	94,635	86,256	79,027	79,422
At gas processing plants	1,077	1,243	1,063	704
Total production	95,712	87,499	80,090	80,126
Stocks end of year:				
At refineries	27,564	24,237	19,068	20,985
At plants	284	201	43	37
Total stocks	27,848	24,438	19,111	21,022
Imports	1,451	189	526	785
Exports	121	181	91	85
Domestic demand	95,974	90,917	85,852	78,915
Distillate fuel oil:				
Production:				
At refineries	895,656	910,727	962,405	1,029,343
At gas processing plants	1,441	1,370	1,220	835
Total production	897,097	912,097	963,625	1,030,178
Crude used directly as distillate	743	1,548	944	760
Stocks end of year:				
At refineries	195,213	190,584	[2] 154,284	[2] 196,421
At plants	58	38	35	40
Total stocks	195,271	190,622	154,319	196,461
Imports	53,826	55,783	66,449	138,752
Exports	898	2,761	1,211	3,240
Domestic demand	927,211	971,316	1,066,110	1,124,308
Residual fuel oil:				
Production	257,510	274,684	292,519	354,597
Crude used directly as residual	4,317	4,565	3,322	6,126
Stocks end of year	53,994	59,681	55,216	53,480
Imports	557,845	577,700	[4] 637,401	[4] 666,706
Exports	19,785	13,217	12,060	9,231
Domestic demand	804,288	838,045	925,647	1,019,934
Petrochemical feedstocks (excluding LRG): [3]				
Production	100,381	110,948	124,026	132,564
Stocks end of year	3,619	3,886	2,766	2,387
Imports: Naphtha–400°	5,352	5,109	3,178	3,825
Exports: Other	3,776	5,265	4,627	5,801
Domestic demand:				
Still gas	12,564	16,158	14,678	12,428
Naphtha–400°	57,279	56,821	58,075	56,822
Other	31,340	37,546	50,944	61,717
Total domestic demand	101,183	110,525	123,697	130,967

See footnotes at end of table.

Table 30.—Salient statistics of the major refined petroleum products in the United States—Continued

(Thousand barrels)

Product	1970	1971	1972	1973 p
Special naphthas:				
Production:				
At refineries	30,196	28,255	32,096	32,873
At gas processing plants	384	329	264	210
Total production	30,580	28,584	32,360	33,083
Stocks end of year:				
At refineries	6,184	5,373	5,224	4,514
At plants	9	11	8	7
Total stocks	6,193	5,384	5,232	4,521
Imports	2,297	1,824	863	88
Exports	1,586	1,455	1,509	1,652
Domestic demand	31,390	29,762	31,866	32,230
Lubricants:				
Production	66,183	65,473	65,349	68,742
Stocks end of year	14,712	15,049	13,271	12,186
Imports	224	10	669	2,032
Exports:				
Grease	293	235	227	251
Oil	15,797	15,590	14,756	12,571
Total exports	16,090	15,825	14,983	12,822
Domestic demand	49,693	49,321	52,813	59,037
Wax (1 barrel=280 lbs.):				
Production	6,294	6,939	6,148	6,768
Stocks end of year	993	1,117	1,061	990
Imports	117	93	335	1,067
Exports	1,808	1,660	1,130	965
Domestic demand	4,607	5,248	5,409	6,941
Coke (5 barrels=1 short ton):				
Production:				
Marketable coke	59,107	62,313	66,814	67,527
Catalyst coke	48,764	46,801	52,951	64,763
Total production	107,871	109,114	119,765	132,290
Stocks end of year	5,297	7,445	7,816	9,974
Exports	30,557	27,069	31,118	35,006
Domestic demand	77,215	79,897	88,276	95,126
Asphalt (5.5 barrels=1 short ton):				
Production	146,658	157,039	155,294	167,884
Stocks end of year	15,779	21,202	21,638	15,024
Imports	6,201	7,216	9,263	8,444
Exports	356	306	333	340
Domestic demand	153,477	158,526	163,788	182,602
Road oil:				
Production	9,393	8,755	7,943	7,326
Stocks end of year	632	900	1,305	799
Domestic demand	9,641	8,487	7,538	7,832
Still gas for fuel:				
Production	163,905	156,967	170,993	176,758
Miscellaneous products:				
Production:				
At refineries	14,746	14,271	15,364	18,795
At gas processing plants	924	1,156	1,028	1,066
Total production	15,670	15,427	16,392	19,861
Stocks end of year:				
At refineries	2,105	1,593	1,632	1,378
At plants	15	11	22	16
Total stocks	2,120	1,604	1,654	1,394
Exports	1,071	1,028	1,058	1,183
Domestic demand	14,843	14,915	15,284	18,938
Unfinished oils (net):				
Input (+) Output (−)	+38,091	+43,608	+51,518	+45,768
Stocks end of year	98,989	100,574	94,761	99,154
Imports	39,261	45,193	45,705	50,161

p Preliminary.

[1] Includes underground stocks at plants and refineries, in thousands of barrels. At plants: Ethane, 1972, 6,143; 1973, 3,921; propane, 1972, 39,340; 1973, 52,090; butane, 1972, 7,917; 1973, 12,243; butane-propane mixture, 1972, 324; 1973 192; and isobutane, 1972, 7,407; 1973, 6,341. At refineries (includes LRG): Propane, 1972, 4,427; 1973, 4,074; butane, 1972, 3,176; 1973, 2,725; butane-propane mixture, 1972, 260; 1973, 444; and isobutane, 1972, 1,236; 1973, 765.

[2] Includes No. 4 fuel oil, in thousands of barrels: 1972, 3,723; 1973, 3,449. Data for previous years are not available.

[3] Produced at petroleum refineries. Data for LRG petrochemical feedstocks are included with those for "Liquefied gases."

[4] Includes foreign crude oil to be burned as fuel, in thousands of barrels. 1972, 10,419,000; 1973, 19,105.

Note: "Stocks at refineries" include stocks at refineries and bulk terminals operated by refining and refined products pipeline companies, including pipeline fill. "Stocks at plants" include stocks at plants and terminals operated by natural gas processing companies and natural gas liquids stocks at terminals of pipeline companies, including pipeline fill.

Table 31.—Stocks of refined petroleum products (including unfinished oils) in the United States at end of month

(Thousand barrels)

	January	February	March	April	May	June	July	August	September	October	November	December
1972												
Gasoline:												
Motor	239,912	250,236	237,177	225,552	215,089	200,353	200,975	192,967	199,927	207,915	209,032	212,894
Aviation	4,679	4,573	4,036	3,994	4,080	3,930	3,696	3,784	3,769	3,825	4,134	4,255
Total gasoline	244,591	254,809	241,213	229,546	219,169	204,283	204,671	196,751	203,696	211,740	213,166	217,149
Jet fuel:												
Naphtha type	6,658	6,339	6,966	6,471	6,093	5,889	5,844	6,517	6,149	5,933	5,647	6,147
Kerosine type	19,199	18,891	20,181	21,097	22,792	22,467	23,585	25,132	24,448	22,700	21,003	19,346
Total jet fuel	25,857	25,230	27,147	27,568	28,885	28,356	29,429	31,649	30,597	28,633	26,650	25,493
Ethane (including ethylene)	3,265	3,677	4,112	4,589	5,127	5,423	5,690	5,888	6,086	6,170	6,719	7,052
Liquefied gases [1]	79,161	68,206	68,575	75,362	87,601	95,787	104,150	109,003	113,265	109,323	96,448	78,665
Kerosine	21,339	17,408	15,693	16,363	17,132	18,640	21,481	22,060	22,917	21,956	21,351	19,111
Distillate fuel oil	160,073	122,194	101,765	98,324	112,926	128,779	155,593	174,702	190,289	195,570	182,619	154,319
Residual fuel oil	59,440	50,891	51,566	49,425	53,035	56,109	60,230	61,399	63,692	63,758	57,702	55,216
Petrochemical feedstocks	3,236	3,115	2,801	3,094	2,852	2,831	2,727	2,824	2,749	2,355	2,721	2,766
Special naphthas	5,594	5,575	4,903	5,231	5,087	4,585	4,842	4,958	5,025	4,818	5,132	5,232
Lubricants	15,325	15,136	14,429	13,722	13,729	13,895	13,426	13,283	13,278	13,249	12,856	13,271
Wax	1,121	1,097	1,106	1,067	1,024	970	1,031	993	1,014	1,038	1,036	1,061
Coke	8,049	8,798	8,006	7,747	7,686	7,944	8,304	8,067	7,742	7,848	7,423	7,816
Asphalt	24,072	26,557	29,245	31,037	30,979	28,590	26,365	20,727	18,828	17,208	18,447	21,638
Road oil	1,021	1,291	1,752	2,030	1,950	2,042	1,846	1,663	1,460	1,284	1,270	1,305
Miscellaneous	1,620	1,521	1,315	1,266	1,460	1,571	1,780	1,474	1,682	1,702	1,557	1,654
Unfinished oils	102,763	99,110	103,137	106,890	109,535	114,054	109,574	104,871	106,043	103,482	101,221	94,761
Total 1972	756,527	704,615	676,765	673,261	698,177	713,859	751,139	760,312	788,363	790,134	756,318	706,509
1973												
Gasoline:												
Motor	221,954	216,484	207,732	204,877	202,201	208,466	211,572	205,189	210,359	214,610	207,418	209,478
Aviation	4,024	3,551	3,349	3,309	3,109	3,089	3,437	3,417	3,529	3,598	3,982	3,939
Total gasoline	225,978	220,035	211,081	208,186	205,310	211,555	215,009	208,606	213,888	218,208	211,400	213,417
Jet fuel:												
Naphtha type	5,953	5,486	5,899	5,209	5,055	4,603	4,280	4,268	4,652	4,242	4,939	5,599
Kerosine type	18,861	19,951	21,686	22,672	20,770	20,844	21,381	20,583	20,497	21,335	23,600	22,945
Total jet fuel	24,814	25,437	27,585	27,881	25,825	25,447	25,661	24,851	25,149	25,577	28,539	28,544
Ethane (including ethylene)	7,139	7,126	7,173	6,869	6,976	6,733	6,734	6,374	6,193	6,139	5,381	5,023
Liquefied gases [1]	62,083	52,756	56,584	63,572	73,062	83,315	94,296	100,476	105,067	105,116	98,834	93,618
Kerosine	16,038	14,612	16,404	18,088	19,148	20,160	20,477	21,590	22,105	23,549	21,203	21,022
Distillate fuel oil	130,993	113,310	111,299	114,723	119,131	137,869	160,901	177,304	190,209	203,000	200,218	196,461
Residual fuel oil	49,154	43,058	44,711	47,044	49,207	51,811	53,363	53,586	55,091	54,964	51,985	53,480
Petrochemical feedstocks	2,618	2,848	3,057	3,029	2,737	2,859	2,638	2,360	2,256	2,620	2,442	2,387
Special naphthas	5,038	4,576	4,491	4,860	4,316	4,242	4,520	4,328	4,450	4,337	4,383	4,521
Lubricants	13,397	13,341	13,279	13,441	12,910	12,770	12,209	11,765	11,805	11,623	12,057	12,186
Wax	1,058	989	947	1,006	917	920	941	922	874	913	926	990
Coke	8,599	8,976	9,739	9,475	9,609	9,824	10,287	10,435	10,136	9,783	10,087	9,974
Asphalt	24,345	26,995	29,775	31,002	30,247	27,330	22,870	16,756	14,900	12,469	12,055	15,024
Road oil	1,396	1,496	1,781	2,094	2,014	1,814	1,535	1,112	1,035	866	723	799
Miscellaneous	1,636	1,700	1,523	1,621	1,701	1,526	1,707	1,758	1,838	1,716	1,352	1,394
Unfinished oils	87,767	87,583	97,646	104,956	105,404	103,615	102,307	98,925	101,904	102,499	103,586	99,154
Total 1973	662,053	624,838	637,075	657,847	668,514	701,790	735,455	741,148	766,900	783,379	765,171	757,994

[1] Includes LRG used for petrochemical feedstocks.

Table 32.—Input and output of petroleum products at refineries in the United States

(Thousand barrels)

	1969	1970	1971	1972	1973 p
INPUT					
Crude petroleum:					
Domestic	3,363,602	3,485,332	3,481,543	3,473,880	3,359,946
Foreign [1]	516,003	482,171	606,266	806,983	1,177,308
Total crude petroleum	3,879,605	3,967,503	4,087,809	4,280,863	4,537,254
Unfinished oils rerun (net)	34,346	38,091	43,608	51,518	45,768
Total crude and unfinished oils rerun	3,913,951	4,005,594	4,131,417	4,332,381	4,583,022
Natural gas liquids:					
Liquefied petroleum gases	72,764	80,307	79,695	85,193	80,221
Natural gasoline	157,492	163,976	166,222	164,062	160,350
Plant condensate	34,332	34,051	39,020	53,190	56,911
Total natural gas liquids	264,588	278,334	284,937	302,445	297,482
Other hydrocarbons and hydrogen [2]	4,213	6,238	6,074	10,118	10,716
OUTPUT					
Gasoline:					
Motor gasoline [3]	1,995,947	2,080,199	2,179,093	2,298,775	2,382,418
Aviation gasoline	26,460	19,712	18,457	16,993	16,413
Total gasoline [3]	2,022,407	2,099,911	2,197,550	2,315,768	2,398,831
Jet fuel:					
Naphtha type [3]	104,748	84,060	85,317	76,565	65,997
Kerosine type	216,952	217,832	219,348	233,464	247,692
Total jet fuel [3]	321,700	301,892	304,665	310,029	313,689
Ethane (including ethylene)	9,159	9,460	9,266	9,197	9,194
Liquefied refinery gas:					
For fuel use	75,659	80,870	88,648	84,514	89,570
For chemical use	38,703	35,657	32,304	36,668	38,062
Total liquefied refinery gas	114,362	116,527	120,952	121,182	127,632
Kerosine [3]	101,738	94,635	86,256	79,027	79,422
Distillate fuel oil [3]	846,863	895,656	910,727	962,405	1,029,343
Residual fuel oil	265,906	257,510	274,684	292,519	354,597
Petrochemical feedstocks:					
Still gas	9,985	12,564	16,158	14,678	12,428
Naphtha-400°	57,389	54,154	54,096	57,027	57,155
Other	30,982	33,663	40,694	52,321	62,981
Total petrochemical feedstocks	98,356	100,381	110,948	124,026	132,564
Special naphthas [3]	28,397	30,196	28,255	32,096	32,873
Lubricants	65,080	66,183	65,473	65,349	68,742
Wax [4]	6,049	6,294	6,939	6,148	6,768
Coke [4]	102,868	107,871	109,114	119,765	132,290
Asphalt [4]	135,691	146,658	157,039	155,294	167,884
Road oil	9,086	9,393	8,755	7,943	7,326
Still gas for fuel	160,363	163,905	156,967	170,993	176,758
Miscellaneous [3]	17,139	14,746	14,271	15,364	18,795
Processing gain (—) or loss (+)	—122,412	—131,052	—139,433	—142,161	—165,488

p Preliminary.
[1] Includes some Athabasca hydrocarbons.
[2] "Other hydrocarbons and hydrogen" is defined as including all hydrogen, process natural gas, tar sand bitumen, gilsonite, shale oil, and other naturally occurring hydrocarbon mixtures consumed as raw materials in the production of finished products.
[3] Production at gas-processing plants shown as direct transfers and omitted from the input and output at refineries.
[4] Conversion factors: 280 pounds of wax to the barrel; 5.0 barrels of coke to the short ton; 5.5 barrels of asphalt to the short ton.

Table 33.—Input and output at refineries in the United States, by month

(Thousand barrels)

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
INPUT 1972													
Crude petroleum:													
Domestic	288,758	268,078	288,230	278,197	292,840	289,416	303,350	303,162	289,560	291,916	282,723	297,650	3,473,880
Foreign	64,277	61,254	63,473	57,336	62,966	65,820	65,095	66,215	73,804	76,083	72,815	77,845	[1] 806,983
Total crude petroleum	353,035	329,332	351,703	335,533	355,806	355,236	368,445	369,377	363,364	367,999	355,538	375,495	4,280,863
Unfinished oils rerun (net)	+3,331	+7,842	−793	−211	−150	−1,508	+7,819	+8,303	+2,784	+6,775	+6,107	+11,219	+51,518
Total crude and unfinished oils rerun	356,366	337,174	350,910	335,322	355,656	353,728	376,264	377,680	366,148	374,774	361,645	386,714	4,322,381
Natural gas liquids:													
Liquefied petroleum gases	9,243	8,450	7,196	6,062	5,853	5,298	5,734	5,554	6,046	7,858	9,187	8,712	85,193
Natural gasoline	13,082	12,382	13,735	13,654	14,167	14,221	14,211	14,157	14,242	14,295	13,125	12,791	164,062
Plant condensate	3,478	3,573	4,210	3,535	4,493	4,337	4,677	4,810	4,750	4,795	5,197	5,335	53,190
Total natural gas liquids	25,803	24,405	25,141	23,251	24,513	23,856	24,622	24,521	25,038	26,948	27,509	26,838	302,445
Other hydrocarbons	578	614	883	808	732	808	862	1,012	757	1,006	1,167	891	10,118
OUTPUT 1972													
Gasoline:													
Motor gasoline [2]	190,678	173,682	183,297	174,997	186,714	187,331	204,967	204,215	198,159	202,491	193,095	199,149	2,298,775
Aviation gasoline	1,550	1,201	1,217	1,442	1,500	1,363	1,311	1,606	1,358	1,746	1,459	1,240	16,993
Total gasoline [2]	192,228	174,883	184,514	176,439	188,214	188,694	206,278	205,821	199,517	204,237	194,554	200,389	2,315,768
Jet fuel:													
Naphtha type [2]	5,696	6,596	6,921	7,020	6,873	6,825	6,416	6,793	5,833	6,077	5,742	5,773	76,565
Kerosine type	18,618	19,498	21,178	19,275	20,638	18,940	20,660	19,162	18,478	19,407	18,247	19,363	233,464
Total jet fuel [2]	24,314	26,094	28,099	26,295	27,511	25,765	27,076	25,955	24,311	25,484	23,989	25,136	310,029
Ethane (including ethylene)	820	824	821	786	737	715	783	757	723	811	718	702	9,197
Liquefied gases:													
LRG for fuel use	6,735	6,730	7,372	7,045	7,182	6,930	7,469	7,462	7,157	6,913	6,640	6,879	84,514
LRG for chemical use	2,955	2,846	2,957	3,003	3,373	3,191	3,292	3,209	2,888	2,972	2,719	3,263	36,668
Total liquefied gases	9,690	9,576	10,329	10,048	10,555	10,121	10,761	10,671	10,045	9,885	9,359	10,142	121,182
Kerosine [2]	8,628	6,658	6,966	5,859	5,098	4,897	5,571	5,757	6,648	6,294	7,772	8,879	79,027
Distillate fuel oil [2]	78,674	76,928	79,480	74,291	80,145	78,692	78,394	80,051	78,712	84,369	81,584	91,085	962,405
Residual fuel oil	28,646	27,929	25,662	22,169	20,591	19,820	20,863	20,882	21,295	23,092	26,711	34,859	292,519
Petrochemical feedstocks:													
Still gas	1,230	1,055	1,033	935	1,095	1,147	1,378	1,444	1,144	1,500	1,360	1,357	14,678
Naphtha-400°	4,646	4,390	4,380	5,005	4,723	4,866	4,685	5,041	4,303	4,575	4,957	5,456	57,027
Other	3,920	4,057	3,907	4,742	4,164	3,567	4,253	4,499	4,751	4,972	4,729	4,760	52,321
Total petrochemical feedstocks	9,796	9,502	9,320	10,682	9,982	9,580	10,316	10,984	10,198	11,047	11,046	11,573	124,026
Special naphthas [2]	2,502	2,466	2,663	2,753	2,674	2,383	2,864	2,997	2,791	2,546	2,636	2,821	32,096
Lubricants:													
Bright stock	614	584	559	463	542	511	554	530	492	563	572	556	6,540
Neutral	2,402	2,159	2,381	2,452	2,611	2,643	2,378	2,729	2,329	2,433	2,381	2,365	29,263
Other grades	2,451	2,184	2,456	2,280	2,543	2,440	2,466	2,526	2,516	2,631	2,438	2,615	29,546
Total lubricants	5,467	4,927	5,396	5,195	5,696	5,594	5,398	5,785	5,337	5,627	5,391	5,536	65,349

See footnotes at end of table.

Table 33.—Input and output at refineries in the United States, by month—Continued

(Thousand barrels)

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
OUTPUT 1972—Continued													
Wax:													
Microcrystalline	65	101	101	69	68	80	81	79	82	74	78	77	955
Crystalline-fully refined	250	265	335	232	260	241	253	278	244	273	260	276	3,167
Crystalline-other	197	128	135	170	220	173	183	170	188	162	166	134	2,026
Total wax [3]	512	494	571	471	548	494	517	527	514	509	504	487	6,148
Coke [3]	9,492	9,414	9,562	8,850	9,065	9,104	9,421	11,196	10,558	11,094	10,739	11,270	119,765
Asphalt [3]	8,150	8,125	9,954	11,373	14,926	15,992	17,051	17,492	16,632	15,094	11,392	9,113	155,294
Road oil	288	356	635	613	768	1,139	1,151	1,151	836	595	273	138	7,943
Still gas for fuel	13,814	12,700	13,514	13,375	13,977	14,381	15,171	15,589	14,642	14,573	14,308	14,949	170,993
Miscellaneous products [2]	1,227	1,145	1,256	1,159	1,221	1,133	1,332	1,424	1,469	1,288	1,388	1,322	15,364
Processing gain (−) or loss (+)	−11,501	−9,828	−11,808	−10,977	−10,807	−10,112	−11,199	−13,826	−12,285	−13,817	−12,043	−13,958	−142,161
INPUT 1973 p													
Crude petroleum:													
Domestic	292,755	260,792	283,168	274,790	281,760	286,783	290,839	284,383	269,706	282,613	270,389	281,968	3,359,946
Foreign	85,148	80,452	95,053	91,449	98,942	99,086	104,397	107,316	107,083	112,878	100,835	94,669	[1] 1,177,308
Total crude petroleum	377,903	341,244	378,221	366,239	380,702	385,869	395,236	391,699	376,789	395,491	371,224	376,637	4,537,254
Unfinished oils rerun (net)	+10,272	+2,663	−5,882	−2,524	+3,554	+6,431	+5,783	+7,897	+1,622	+2,993	+3,866	+9,093	+45,768
Total crude and unfinished oils rerun	388,175	343,907	372,339	363,715	384,256	392,300	401,019	399,596	378,411	398,484	375,090	385,730	4,583,022
Natural gas liquids:													
Liquefied petroleum gases	8,666	6,982	6,377	5,238	5,285	5,494	5,934	6,617	6,254	7,483	7,853	8,038	80,221
Natural gasoline	12,336	11,425	12,935	11,906	12,888	12,899	15,297	15,164	14,305	13,940	13,863	13,392	160,350
Plant condensate	5,009	4,988	5,183	4,837	4,549	4,306	5,087	4,819	4,433	4,460	4,574	4,666	56,911
Total natural gas liquids	26,011	23,395	24,495	21,981	22,722	22,699	26,318	26,600	24,992	25,883	26,290	26,096	297,482
Other hydrocarbons	856	942	1,000	700	989	846	978	948	905	895	749	908	10,716
OUTPUT 1973 p													
Gasoline:													
Motor gasoline [2]	196,571	171,940	190,648	191,315	208,147	209,792	216,572	213,277	198,580	205,249	191,259	189,068	2,382,418
Aviation gasoline	1,001	775	1,180	1,241	1,378	1,335	1,562	1,942	1,444	1,654	1,753	1,148	16,413
Total gasoline [2]	197,572	172,715	191,828	192,556	209,525	211,127	218,134	215,219	200,024	206,903	193,012	190,216	2,398,831
Jet fuel:													
Naphtha type [2]	5,281	4,589	6,057	5,955	6,005	5,344	4,833	5,371	5,578	5,278	4,905	6,801	65,997
Kerosine type	21,506	20,567	22,369	20,658	20,031	19,731	20,739	20,802	19,841	21,851	20,668	18,929	247,692
Total jet fuel [2]	26,787	25,156	28,426	26,613	26,036	25,075	25,572	26,173	25,419	27,129	25,573	25,730	313,689
Ethane (including ethylene)	722	659	736	687	892	849	842	898	717	713	759	720	9,194
Liquefied gases:													
LRG for fuel use	7,191	6,574	7,606	7,488	8,753	7,745	8,467	7,929	6,952	7,683	6,303	6,879	89,570
LRG for chemical use	3,275	2,826	3,382	3,015	3,394	3,050	3,402	3,264	3,421	3,285	2,873	2,875	38,062
Total liquefied gases	10,466	9,400	10,988	10,503	12,147	10,795	11,869	11,193	10,373	10,968	9,176	9,754	127,632

Kerosine [2]	9,446	9,290	7,931	6,507	5,093	4,486	4,874	5,392	5,849	6,963	6,553	7,038	79,422
Distillate fuel oil [2]	93,862	82,242	82,679	75,306	78,860	84,759	85,299	86,840	84,379	90,230	87,672	97,215	1,029,343
Residual fuel oil	34,472	29,053	29,592	26,315	29,392	27,448	27,352	26,368	26,338	30,517	31,840	35,910	354,597
Petrochemical feedstocks:													
Still gas	1,327	840	1,183	1,019	1,222	1,054	916	1,188	1,015	884	902	878	12,428
Naphtha–400°	4,780	4,751	4,509	4,815	3,943	4,329	4,655	4,648	4,816	5,106	5,066	5,737	57,155
Other	4,821	4,495	5,270	5,337	5,040	5,572	5,468	5,351	4,998	5,620	5,548	5,461	62,981
Total petrochemical feedstocks	10,928	10,086	10,962	11,171	10,205	10,955	11,039	11,187	10,829	11,610	11,516	12,076	132,564
Special naphthas [2]	2,742	2,320	2,802	2,499	2,697	2,673	3,126	2,867	2,720	2,977	2,628	2,822	32,873
Lubricants:													
Bright stock	572	520	703	652	609	558	705	571	546	669	606	770	7,481
Neutral	2,772	2,349	2,611	2,376	2,380	2,375	2,338	2,495	2,348	2,621	2,624	2,675	29,964
Other grades	2,396	2,546	2,555	2,457	2,783	2,477	2,749	2,534	2,566	2,881	2,792	2,561	31,297
Total lubricants	5,740	5,415	5,869	5,485	5,772	5,410	5,792	5,600	5,460	6,171	6,022	6,006	68,742
Wax:													
Microcrystalline	78	66	81	83	87	115	100	105	97	112	106	103	1,133
Crystalline-fully refined	280	189	231	254	298	250	231	282	279	294	327	288	3,203
Crystalline-other	178	159	222	176	188	174	231	187	182	240	250	245	2,432
Total wax [3]	536	414	534	513	573	539	562	574	558	646	683	636	6,768
Coke [3]	11,412	10,061	11,135	10,875	11,146	11,574	11,755	11,546	10,335	11,077	10,497	10,877	132,290
Asphalt [3]	7,919	8,336	10,109	12,082	14,702	16,799	17,689	18,925	18,104	17,823	14,029	11,367	167,884
Road oil	192	192	476	555	662	1,046	999	1,117	890	678	305	214	7,326
Still gas for fuel	15,018	13,129	14,901	14,420	14,854	15,665	16,258	15,911	14,487	14,768	13,369	13,978	176,758
Miscellaneous products [2]	1,416	1,252	1,318	1,514	1,947	1,462	1,749	1,913	1,578	1,685	1,402	1,559	18,795
Processing gain (−) or loss (+)	−14,188	−11,476	−12,452	−11,205	−16,536	−14,817	−14,596	−14,579	−13,752	−15,596	−12,907	−13,384	−165,488

[p] Preliminary.
[1] Includes some Athabasca hydrocarbons.
[2] Production at gas-processing plants shown as direct transfers and omitted from the input and output at refineries.
[3] Conversion factors: 280 pounds of wax to the barrel; 5.0 barrels of coke to the short ton; 5.5 barrels of asphalt to the short ton.

Table 34.—Input and output at refineries

(Thousand

Item	PAD district I			PAD district II				
	East Coast	Appalachian No. 1	Total	Appalachian No. 2	Ind., Ill., etc.	Minn., Wisc., etc.	Okla., Kans., etc.	Total
INPUT 1972								
Crude petroleum:								
Domestic	108,520	18,588	127,108	17,216	677,852	22,508	325,439	1,043,015
Foreign	315,266	40,100	355,366	2,392	[1] 100,952	60,824	4,565	168,733
Total crude petroleum	423,786	58,688	482,474	19,608	778,804	83,332	330,004	1,211,748
Unfinished oils rerun (net)	+57,479	+182	+57,661	+30	+40	−36	+1,228	+1,262
Total crude and unfinished oils rerun	481,265	58,870	540,135	19,638	778,844	83,296	331,232	1,213,010
Natural gas liquids:								
Liquefied petroleum gases	251	90	341	--	11,750	3,415	11,107	26,272
Natural gasoline	889	9	898	--	7,162	1,603	11,417	20,182
Plant condensate	487	960	1,447	475	13,497	6,618	--	20,590
Total natural gas liquids	1,627	1,059	2,686	475	32,409	11,636	22,524	67,044
Other hydrocarbons	--	--	--	--	264	--	275	539
OUTPUT 1972								
Gasoline:								
Motor gasoline [2]	235,576	25,127	260,703	10,060	438,817	48,550	199,940	697,367
Aviation gasoline	355	--	355	--	1,670	--	539	2,209
Total gasoline [2]	235,931	25,127	261,058	10,060	440,487	48,550	200,479	699,576
Jet fuel:								
Naphtha type [2]	1,454	650	2,104	--	7,552	1,446	6,686	15,684
Kerosine type	10,545	678	11,223	--	35,421	1,397	10,404	47,222
Total jet fuel [2]	11,999	1,328	13,327	--	42,973	2,843	17,090	62,906
Ethane (including ethylene)	--	--	--	--	--	--	590	590
Liquefied gases:								
LRG for fuel use	10,991	1,432	12,423	324	14,400	1,284	7,109	23,117
LRG for chemical use	5,497	--	5,497	--	2,634	222	1,170	4,026
Total liquefied gases	16,488	1,432	17,920	324	17,034	1,506	8,279	27,143
Kerosine [2]	6,190	1,614	7,804	781	15,041	1,339	2,932	20,093
Distillate fuel oil [2]	118,572	13,916	132,488	5,038	168,356	22,781	79,897	276,072
Residual fuel oil	30,873	6,709	37,582	1,730	50,219	7,016	6,883	65,848
Petrochemical feedstocks:								
Still gas	945	74	1,019	--	2,610	--	2,070	4,680
Naphtha-400°	5,392	--	5,392	--	4,241	--	2,147	6,388
Other	66	665	731	--	2,293	--	451	2,744
Total petrochemical feedstocks	6,403	739	7,142	--	9,144	--	4,668	13,812
Special naphthas [2]	200	339	539	282	3,755	--	1,330	5,367
Lubricants:								
Bright stock	356	1,301	1,657	--	498	--	654	1,152
Neutral	2,903	2,439	5,342	12	3,260	--	3,180	6,452
Other grades	3,606	389	3,995	--	1,498	--	1,418	2,916
Total lubricants	6,865	4,129	10,994	12	5,256	--	5,252	10,520
Wax:								
Microcrystalline	171	237	408	--	9	--	265	274
Crystalline-fully refined	828	148	976	--	205	--	246	451
Crystalline-other	261	421	682	--	192	--	104	296
Total wax [3]	1,260	806	2,066	--	406	--	615	1,021
Coke [3]	13,187	236	13,423	129	20,229	3,405	10,404	34,167
Asphalt [3]	28,087	1,620	29,707	1,447	31,487	6,340	14,578	53,852
Road oil	49	619	668	--	2,735	207	938	3,880
Still gas for fuel	19,403	2,127	21,530	697	31,335	1,423	10,609	44,064
Miscellaneous products [2]	2,192	171	2,363	41	1,444	133	1,312	2,930
Processing gain (−) or loss (+)	−14,807	−983	−15,790	−428	−28,384	−611	−11,825	−41,248

See footnotes at end of table.

in the United States by district

barrels)

PAD district III						PAD district IV	PAD district V	United States
Tex. Inland	Tex. Gulf	La. Gulf	Ark., La., Inland etc.	N. Mex.	Total	Other Rocky Mt.	West Coast	
151,737	937,758	581,455	48,072	16,261	1,735,283	131,990	436,484	3,473,880
--	23,465	4,194	--	--	27,659	13,425	241,800	[1] 806,983
151,737	961,223	585,649	48,072	16,261	1,762,942	145,415	678,284	4,280,863
−72	−23,761	+2,639	+738	−9	−20,465	−940	+14,000	+51,518
151,665	937,462	588,288	48,810	16,252	1,742,477	144,475	692,284	4,332,381
8,764	18,418	19,037	1,168	672	48,059	3,272	7,249	85,193
16,396	89,005	24,203	1,034	555	131,193	1,603	10,186	164,062
24	12,121	2,026	2,076	--	16,247	11,376	3,530	53,190
25,184	119,544	45,266	4,278	1,227	195,499	16,251	20,965	302,445
233	192	2,898	53	--	3,376	131	6,072	10,118
101,350	500,833	308,750	20,370	9,041	940,344	80,432	319,929	2,298,775
2,053	5,279	2,648	--	--	9,980	453	3,996	16,993
103,403	506,112	311,398	20,370	9,041	950,324	80,885	323,925	2,315,768
5,084	12,487	7,692	1,553	2,073	28,889	4,079	25,809	76,565
9,040	53,702	47,540	8	50	110,340	4,513	60,166	233,464
14,124	66,189	55,232	1,561	2,123	139,229	8,592	85,975	310,029
104	4,802	3,147	--	--	8,053	3	551	9,197
3,317	17,195	13,175	549	455	34,691	2,193	12,090	84,514
261	13,750	8,236	399	4	22,650	55	4,440	36,668
3,578	30,945	21,411	948	459	57,341	2,248	16,530	121,182
1,296	28,865	16,754	744	103	47,762	1,844	1,524	79,027
28,535	233,079	147,767	11,498	3,299	424,178	38,024	91,643	962,405
3,608	37,682	18,695	4,428	634	65,047	9,152	114,890	292,519
274	7,647	79	5	12	8,017	226	736	14,678
1,461	38,732	337	--	--	40,530	--	4,717	57,027
3,469	20,063	21,882	225	--	45,639	79	3,128	52,321
5,204	66,442	22,298	230	12	94,186	305	8,581	124,026
1,219	18,014	307	1,269	--	20,809	205	5,176	32,096
--	1,512	751	--	--	2,263	57	1,411	6,540
--	8,440	5,645	887	--	14,972	195	2,302	29,263
98	18,024	1,298	1,169	--	20,589	143	1,903	29,546
98	27,976	7,694	2,056	--	37,824	395	5,616	65,349
69	141	53	--	--	263	10	--	955
--	611	509	--	--	1,120	63	557	3,167
--	834	64	--	--	898	27	123	2,026
69	1,586	626	--	--	2,281	100	680	6,148
2,811	21,687	14,342	958	176	39,974	3,559	28,642	119,765
7,107	8,533	15,660	8,156	1,019	40,475	10,364	20,896	155,294
69	33	--	--	--	102	1,144	2,149	7,943
5,581	37,219	22,426	1,482	548	67,256	5,424	32,719	170,993
2,249	4,216	1,248	92	--	7,805	77	2,189	15,364
−1,973	−36,182	−22,553	−651	+65	−61,294	−1,464	−22,365	−142,161

Table 34.—Input and output at refineries

(Thousand

Item	PAD district I			PAD district II				
	East Coast	Appalachian No. 1	Total	Appalachian No. 2	Ind., Ill., etc.	Minn., Wisc., etc.	Okla., Kans., etc.	Total
INPUT 1973 p								
Crude petroleum:								
Domestic	67,106	19,505	86,611	10,313	654,928	21,291	326,055	1,012,587
Foreign	417,100	44,316	461,416	9,625	[1] 172,328	67,168	10,290	259,411
Total crude petroleum	484,206	63,821	548,027	19,938	827,256	88,459	336,345	1,271,998
Unfinished oils rerun (net)	+39,209	+282	+39,491	+99	+1,813	−63	−1,646	+203
Total crude and unfinished oils rerun	523,415	64,103	587,518	20,037	829,069	88,396	334,699	1,272,201
Natural gas liquids:								
Liquefied petroleum gases	148	127	275	--	11,948	2,973	11,784	26,705
Natural gasoline	147	6	153	--	4,854	2,717	11,944	19,515
Plant condensate	206	1,920	2,126	826	16,162	7,437	30	24,455
Total natural gas liquids	501	2,053	2,554	826	32,964	13,127	23,758	70,675
Other hydrocarbons	555	--	555	--	273	--	339	612
OUTPUT 1973 p								
Gasoline:								
Motor gasoline [2]	245,194	27,315	272,509	10,854	465,627	51,806	197,844	726,131
Aviation gasoline	423	--	423	--	1,595	--	520	2,115
Total gasoline [2]	245,617	27,315	272,932	10,854	467,222	51,806	198,364	728,246
Jet fuel:								
Naphtha type [2]	1,907	819	2,726	--	5,738	981	5,218	11,937
Kerosine type	11,223	695	11,918	--	38,671	1,490	10,627	50,788
Total jet fuel [2]	13,130	1,514	14,644	--	44,409	2,471	15,845	62,725
Ethane (including ethylene)	58	--	58	--	--	--	520	520
Liquefied gases:								
For fuel use	12,952	1,412	14,364	367	16,638	1,301	7,017	25,323
For chemical use	6,394	--	6,394	--	2,571	221	1,456	4,248
Total liquefied gases	19,346	1,412	20,758	367	19,209	1,522	8,473	29,571
Kerosine [2]	5,079	1,930	7,009	814	15,743	1,242	2,088	19,887
Distillate fuel oil [2]	130,868	16,135	147,003	4,674	182,761	24,612	85,749	297,796
Residual fuel oil	45,238	7,020	52,258	1,758	53,612	8,026	7,724	71,120
Petrochemical feedstocks:								
Still gas	919	23	942	--	2,128	--	543	2,671
Naphtha–400°	4,932	--	4,932	--	4,373	--	2,200	6,573
Other	30	738	768	--	2,304	--	553	2,857
Total petrochemical feedstocks	5,881	761	6,642	--	8,805	--	3,296	12,101
Special naphthas [2]	123	268	391	257	4,563	--	1,286	6,106
Lubricants:								
Bright stock	599	1,396	1,995	--	438	--	1,126	1,564
Neutral	3,302	2,727	6,029	--	3,258	--	2,705	5,963
Other grades	3,711	346	4,057	--	1,684	--	1,514	3,198
Total lubricants	7,612	4,469	12,081	--	5,380	--	5,345	10,725
Wax:								
Microcrystalline	89	282	371	--	1	--	293	294
Crystalline-fully refined	406	134	540	--	315	--	257	572
Crystalline-other	24	498	522	--	249	--	79	328
Total wax [3]	519	914	1,433	--	565	--	629	1,194
Coke [3]	13,205	422	13,627	289	23,731	3,618	11,235	38,873
Asphalt [3]	34,339	2,077	36,416	1,688	33,460	7,517	14,972	57,637
Road oil	--	706	706	--	2,828	--	1,276	4,104
Still gas for fuel	20,618	2,084	22,702	669	31,770	1,476	12,318	46,233
Miscellaneous products [2]	2,106	172	2,278	53	1,571	10	1,291	2,925
Processing gain (−) or loss (+)	−19,268	−1,043	−20,311	−560	−33,323	−777	−11,615	−46,275

p Preliminary.
[1] Includes some Athabasca hydrocarbons.
[2] Production at gas processing plants shown as direct transfers and omitted from the input and output at refineries.
[3] Conversion factors: 280 pounds of wax to the barrel; 5.0 barrels of coke to the short ton; 5.5 barrels of asphalt to the short ton.

in the United States by district—Continued

barrels)

PAD district III: Tex. Inland	PAD district III: Tex. Gulf	PAD district III: La. Gulf	PAD district III: Ark., La., Inland etc.	PAD district III: N. Mex.	PAD district III: Total	PAD district IV: Other Rocky Mt.	PAD district V: West Coast	United States
155,889	887,281	590,266	49,033	16,932	1,699,401	135,410	425,937	3,359,946
--	128,156	16,869	272	--	145,297	16,111	295,073	[1] 1,177,308
155,889	1,015,437	607,135	49,305	16,932	1,844,698	151,521	721,010	4,537,254
−725	−22,501	+15,044	+624	+32	−7,526	+88	+13,512	+45,768
155,164	992,936	622,179	49,929	16,964	1,837,172	151,609	734,522	4,583,022
7,052	13,954	19,864	1,093	615	42,578	3,443	7,220	80,221
15,993	88,679	24,164	869	760	130,465	1,673	8,544	160,350
18	11,893	1,618	3,031	83	16,643	10,125	3,562	56,911
23,063	114,526	45,646	4,993	1,458	189,686	15,241	19,326	297,482
161	144	4,261	153	--	4,719	88	4,742	10,716
97,473	513,108	328,709	20,628	9,479	969,397	82,846	331,535	2,382,418
2,272	4,813	2,597	--	--	9,682	443	3,750	16,413
99,745	517,921	331,306	20,628	9,479	979,079	83,289	335,285	2,398,831
5,579	10,775	7,677	1,610	2,052	27,693	3,493	20,148	65,997
8,004	56,473	49,630	1	65	114,173	4,611	66,202	247,692
13,583	67,248	57,307	1,611	2,117	141,866	8,104	86,350	313,689
108	5,040	2,960	--	--	8,108	--	508	9,194
3,171	17,077	14,199	696	364	35,507	2,174	12,202	89,570
228	15,723	6,935	328	5	23,219	62	4,139	38,062
3,399	32,800	21,134	1,024	369	58,726	2,236	16,341	127,632
1,130	26,883	20,074	785	131	49,003	2,204	1,319	79,422
31,189	244,178	149,311	11,700	3,601	439,979	41,966	102,599	1,029,343
5,695	53,075	23,755	4,764	1,166	88,455	9,864	132,900	354,597
432	7,341	--	--	--	7,773	161	881	12,428
1,768	38,041	489	--	--	40,298	--	5,352	57,155
3,578	26,135	26,236	241	--	56,190	34	3,132	62,981
5,778	71,517	26,725	241	--	104,261	195	9,365	132,564
1,425	17,716	266	1,603	--	21,010	125	5,241	32,873
--	1,932	662	--	--	2,594	44	1,284	7,481
--	8,577	6,039	851	--	15,467	176	2,329	29,964
108	19,612	1,185	1,133	--	22,038	167	1,837	31,297
108	30,121	7,886	1,984	--	40,099	387	5,450	68,742
79	145	42	194	--	460	8	--	1,133
--	605	744	--	--	1,349	56	686	3,203
--	1,127	146	--	--	1,273	34	275	2,432
79	1,877	932	194	--	3,082	98	961	6,768
3,313	23,718	14,578	640	187	42,436	3,983	33,371	132,290
7,570	9,426	14,731	8,896	810	41,433	10,385	22,013	167,884
64	--	--	--	--	64	770	1,682	7,326
5,837	39,747	22,586	1,373	528	70,071	5,471	32,281	176,758
2,030	5,507	3,187	246	--	10,970	103	2,519	18,795
−2,665	−39,168	−24,652	−614	+34	−67,065	−2,242	−29,595	−165,488

Table 35.—Percentage yields of refined petroleum products from crude oil in the United States[1]

Finished products	1969	1970	1971	1972	1973 p
Gasoline	44.8	45.3	46.2	46.2	45.6
Jet fuel	8.2	7.5	7.4	7.2	6.8
Ethane (including ethylene)	.2	.2	.2	.2	.2
Liquefied gases	2.9	3.0	2.9	2.8	2.8
Kerosine	2.6	2.3	2.1	1.8	1.7
Distillate fuel oil	21.7	22.4	22.0	22.2	22.5
Residual fuel oil	6.8	6.4	6.6	6.8	7.7
Petrochemical feedstocks	2.5	2.5	2.7	2.9	2.9
Special naphthas	.7	.8	.7	.7	.7
Lubricants	1.7	1.6	1.6	1.5	1.5
Wax	.2	.2	.2	.1	.2
Coke	2.6	2.7	2.6	2.8	2.9
Asphalt	3.5	3.6	3.8	3.6	3.6
Road oil	.2	.3	.2	.2	.2
Still gas	4.1	4.1	3.8	3.9	3.9
Miscellaneous	.4	.3	.4	.4	.4
Shortage	−3.1	−3.2	−3.4	−3.3	−3.6
Total	100.0	100.0	100.0	100.0	100.0

p Preliminary.
[1] Other unfinished oils added to crude in computing yields.

Table 36.—Production (refinery output) and consumption of gasoline (excluding naphtha) in the United States, by State

(Thousand barrels)

State	1971		1972		1973 p	
	Production	Consumption [1]	Production	Consumption [1]	Production	Consumption [1]
Alabama	640	40,336	896	43,134	1,184	45,260
Alaska	(2)	2,559	(2)	2,920	(2)	3,232
Arizona	--	24,008	--	26,323	32	28,853
Arkansas	13,580	24,565	7,594	26,773	7,332	27,997
California	[2] 282,262	227,060	[2] 263,533	241,154	[2] 271,374	248,217
Colorado	8,018	28,385	7,766	30,964	7,128	32,449
Connecticut	--	30,238	--	31,810	--	32,365
Delaware	(3)	r 6,690	(3)	6,970	(3)	7,347
District of Columbia	--	5,811	--	5,792	--	6,175
Florida	--	84,671	--	94,194	--	104,265
Georgia	--	59,182	--	64,012	--	67,589
Hawaii	(2)	5,908	(2)	6,344	(2)	6,589
Idaho	--	10,282	--	11,027	--	11,469
Illinois	168,937	109,818	176,948	115,526	221,182	120,557
Indiana	93,782	62,267	99,981	65,881	91,899	68,273
Iowa	--	38,523	--	39,853	--	43,357
Kansas	[4] 99,525	32,453	101,947	34,539	[4] 104,207	34,125
Kentucky	[5] 30,420	36,693	30,675	38,893	[5] 29,493	40,623
Louisiana	236,883	37,204	273,332	40,572	294,307	42,117
Maine	--	11,801	--	12,507	--	12,946
Maryland	--	39,874	--	42,523	--	44,104
Massachusetts	--	51,611	--	54,531	--	56,262
Michigan	27,399	102,688	27,047	109,170	20,509	113,999
Minnesota	29,552	47,808	33,772	50,236	36,768	51,320
Mississippi	39,479	r 26,381	49,946	28,686	49,111	29,530
Missouri	(4)	60,653	(4)	63,522	(4)	65,293
Montana	23,922	10,598	27,053	10,899	27,313	11,305
Nebraska	(4)	r 21,116	(4)	21,838	(4)	22,303
Nevada	--	8,141	--	8,909	--	9,471
New Hampshire	--	8,844	--	9,365	--	9,646
New Jersey	88,276	69,758	92,896	75,928	100,588	77,782
New Mexico	8,594	14,866	9,041	15,729	9,479	16,721
New York	15,281	r 156,770	16,950	144,194	17,534	150,080
North Carolina	(6)	60,702	(6)	65,892	(6)	68,429
North Dakota	[7] 14,691	9,311	[7] 14,778	10,231	[7] 15,038	10,404
Ohio	104,267	112,344	115,896	118,624	114,993	124,301
Oklahoma	97,043	38,232	98,532	39,684	94,157	41,176
Oregon	--	26,722	--	28,541	--	29,695
Pennsylvania	[3] 141,943	107,120	[3] 141,053	114,549	[3] 144,102	116,064
Rhode Island	--	9,512	--	9,843	--	9,984
South Carolina	--	31,511	--	33,624	--	35,200
South Dakota	--	10,594	--	11,203	--	11,402
Tennessee	(5)	46,378	(5)	50,714	(5)	54,675
Texas	598,415	159,997	609,515	168,923	617,666	179,763
Utah	22,678	15,391	21,454	16,405	22,335	16,827
Vermont	--	5,413	--	5,798	--	5,872
Virginia	[6] 8,898	53,992	[6] 10,159	57,365	[6] 10,708	60,667
Washington	19,632	37,671	60,392	39,243	63,879	41,236
West Virginia	(6)	r 17,135	(6)	17,543	(6)	18,586
Wisconsin	(7)	48,113	(7)	51,310	(7)	52,790
Wyoming	23,433	6,322	24,612	6,879	26,513	7,244
Total	2,197,550	r 2,294,022	2,315,768	2,421,089	2,398,831	2,525,936

p Preliminary. r Revised.
1 American Petroleum Institute.
2 Alaska and Hawaii included with California.
3 Delaware included with Pennsylvania.
4 Nebraska and Missouri included with Kansas.
5 Tennessee included with Kentucky.
6 North Carolina and West Virginia included with Virginia.
7 Wisconsin included with North Dakota.

Table 37.—Salient statistics of motor gasoline in the United States, by month and district

(Thousand barrels)

	1972						1973 p					
	Production at refineries	Production at gas processing plants	Imports	Exports	Total stocks (end of period) [1]	Domestic demand	Production at refineries	Production at gas processing plants	Imports	Exports	Total stocks (end of period) [1]	Domestic demand
By month:												
January	190,678	356	1,574	45	239,912	172,003	196,571	327	1,841	32	221,954	189,647
February	173,682	344	1,903	14	250,236	165,591	171,940	288	2,667	142	216,484	180,223
March	183,297	356	2,076	20	237,177	198,768	190,648	330	2,193	22	207,732	201,901
April	174,997	339	1,569	28	225,552	188,502	191,315	301	1,902	130	204,877	196,243
May	186,714	344	2,287	13	215,089	199,795	208,147	307	3,146	151	202,201	214,125
June	187,331	364	2,244	10	200,353	204,665	209,792	199	5,214	28	208,466	208,912
July	204,967	395	2,136	27	200,975	206,849	216,572	211	4,110	70	211,572	217,717
August	204,215	366	2,512	17	192,967	215,084	213,277	212	4,871	8	205,189	224,735
September	198,159	329	2,084	30	199,927	193,582	198,580	218	3;816	27	210,359	197,417
October	202,491	328	2,195	178	207,915	196,848	205,249	218	6,020	252	214,610	206,984
November	193,095	327	2,080	23	209,032	194,362	191,259	205	6,492	460	207,418	204,688
December	199,149	334	2,127	19	212,894	197,729	189,068	213	5,834	146	209,478	192,909
Total	2,298,775	4,182	24,787	424	212,894	2,333,778	2,382,418	3,029	48,106	1,468	209,478	2,435,501
By refining district:												
East Coast	235,576	--	24,609	6	50,587	790,864	245,194	--	42,603	3	53,666	810,515
Appalachian No. 1	25,127	--			5,155		27,315	--			5,225	
Appalachian No. 2	10,060	--	43	3	3,805	807,406	10,854	--	854	6	3,173	843,808
Indiana, Illinois, Kentucky, etc	438,817	--			36,835		465,627	--			35,038	
Minnesota, Wisconsin, etc	48,550	--			7,572		51,806	--			7,893	
Oklahoma, Kansas, etc	199,940	--			17,082		197,844	--			19,298	
Texas Inland	101,350	727	--	264	9,356	323,151	97,473	681	3,510	1,292	8,612	352,485
Texas Gulf Coast	500,833	205			26,631		513,108	209			20,279	
Louisiana Gulf Coast	308,750	1,638			15,035		328,709	1,513			12,847	
Arkansas, Louisiana Inland, etc	20,370	1,612			8,227		20,628	626			11,797	
New Mexico	9,041	--			918		9,479	--			804	
Rocky Mountain	80,432	--	--	--	5,737	68,576	82,846	--	568	--	7,625	74,172
West Coast	319,929	--	135	151	25,954	343,781	331,535	--	571	167	23,221	354,521
Total	2,298,775	4,182	24,787	424	212,894	2,333,778	2,382,418	3,029	48,106	1,468	209,478	2,435,501

p Preliminary.
[1] Includes stocks of gasoline at refineries, bulk terminals and pipelines, and gas processing plants.

Table 38.—Salient statistics of aviation gasoline in the United States, by month and refining district

(Thousand barrels)

	1972				1973 [p]			
	Production	Exports	Stocks (end of period)	Domestic demand	Production	Exports	Stocks (end of period)	Domestic demand
By month:								
January	1,550	48	4,679	1,242	1,001	7	4,024	1,225
February	1,201	9	4,573	1,298	775	12	3,551	1,236
March	1,217	31	4,036	1,723	1,180	67	3,349	1,315
April	1,442	27	3,994	1,457	1,241	4	3,309	1,277
May	1,500	7	4,080	1,407	1,378	6	3,109	1,572
June	1,363	8	3,930	1,505	1,335	6	3,089	1,349
July	1,311	19	3,696	1,526	1,562	12	3,437	1,202
August	1,606	19	3,784	1,499	1,942	49	3,417	1,913
September	1,358	22	3,769	1,351	1,444	8	3,529	1,324
October	1,746	13	3,825	1,677	1,654	10	3,598	1,575
November	1,459	15	4,134	1,135	1,753	8	3,982	1,361
December	1,240	14	4,255	1,105	1,148	9	3,939	1,182
Total	16,993	232	4,255	16,925	16,413	198	3,939	16,531
By refining district:								
East Coast	355	47	566	4,666	423	28	545	3,793
Appalachian No. 1	--		46		--		52	
Appalachian No. 2	--		1		--		1	
Illinois, Indiana, Kentucky, etc	1,670	17	811	3,871	1,595	12	615	4,325
Minnesota, Wisconsin, North Dakota	--		127		--		99	
Oklahoma, Kansas, etc.	539		220		520		204	
Texas Inland	2,053		333		2,272		291	
Texas Gulf Coast	5,279		843		4,813		713	
Louisiana Gulf Coast	2,648	77	429	3,672	2,597	42	646	3,959
Arkansas, Louisiana Inland, etc	--		5		--		2	
New Mexico	--		2		--		16	
Rocky Mountain	453	1	56	688	443	--	54	687
West Coast	3,996	90	816	4,028	3,750	116	701	3,767
Total	16,993	232	4,255	16,925	16,413	198	3,939	16,531

[p] Preliminary.

Table 39.—Shipments of aviation fuels

(Thousand barrels)

Product and use	Shipments to PAD districts					U.S. total
	I	II	III	IV	V	
1972						
Aviation gasoline:						
For commercial use:						
Airlines	385	225	149	28	138	925
Factory	46	39	15	1	51	152
General aviation	2,412	2,839	1,598	457	2,324	9,630
Total	2,843	3,103	1,762	486	2,513	10,707
For military use	2,207	794	1,002	190	1,733	5,926
Jet fuel:						
For commercial use:						
Kerosine type:						
Airlines	92,851	55,057	18,916	6,934	73,185	246,943
Factory	626	554	290	--	645	2,115
General aviation	6,877	2,768	1,675	388	1,052	12,760
Total	100,354	58,379	20,881	7,322	74,882	261,818
Naphtha type:						
Airlines	1,154	7	--	--	3,308	4,469
Factory	1,015	166	20	--	20	1,221
General aviation	493	115	22	2	257	889
Total	2,662	288	42	2	3,585	6,579
Total for commercial use	103,016	58,667	20,923	7,324	78,467	268,397
For military use:						
JP-4	[1] 16,935	16,786	11,183	2,650	[1] 25,153	72,707
JP-5	9,197	249	1,485	--	9,816	20,747
Other	888	12	848	315	568	2,631
Total [1]	27,020	17,047	13,516	2,965	35,537	96,085
For non-aviation use [p]	6,891	1,464	2	55	409	8,821
1973						
Aviation gasoline:						
For commercial use:						
Airlines	575	487	308	16	136	1,522
Factory	45	70	33	6	70	224
General aviation	2,362	2,603	1,803	639	2,355	9,762
Total	2,982	3,160	2,144	661	2,561	11,508
For military use	1,264	975	1,131	63	1,502	4,935
Jet fuel:						
For commercial use:						
Kerosine type:						
Airlines	102,027	57,068	20,317	7,626	72,874	259,912
Factory	858	1,276	292	--	562	2,988
General aviation	3,411	2,532	1,277	423	899	8,542
Total [2]	106,296	60,876	21,886	8,049	74,335	271,442
Naphtha type:						
Airlines	2,503	4	661	--	4,254	7,422
Factory	224	142	15	--	100	481
General aviation	67	184	94	--	59	404
Total	2,794	330	770	--	4,413	8,307
Total for commercial use [2]	109,090	61,206	22,656	8,049	78,748	279,749
For military use:						
JP-4	[2] 13,137	12,939	13,184	3,162	[2] 18,168	60,590
JP-5	[2] 10,783	117	653	--	[2] 13,411	24,964
Other	192	11	3	--	271	477
Total	24,112	13,067	13,840	3,162	31,850	86,031
For non-aviation use [p]	4,630	1,266	150	--	303	6,349

[p] Preliminary.

[1] Excludes direct imports by the military into PAD district I, 6,939,000 barrels; PAD district V, 2,129,000 barrels.

[2] Excludes direct imports by the military of naphtha-type jet into: PAD district I, 8,993,000 barrels; PAD district V, 1,946,000 barrels. Also excludes direct imports by the military of kerosine-type jet into: PAD I, 376,000 barrels; PAD V, 140,000 barrels.

Table 40.—Salient statistics of kerosine in the United States, by month and district

(Thousand barrels unless otherwise stated)

	1972							1973 p						
	Production at refineries	Yield (percent)	Production at gas processing plants	Imports	Exports	Total stocks (end of period)	Domestic demand	Production at refineries	Yield (percent)	Production at gas processing plants	Imports	Exports	Total stocks (end of period)	Domestic demand
By month:														
January	8,628	2.4	97	1	8	21,339	11,817	9,446	2.4	69	6	9	16,038	12,585
February	6,658	2.0	93	24	3	17,408	10,703	9,290	2.7	72	4	8	14,612	10,784
March	6,966	2.0	96	--	8	15,693	8,769	7,931	2.1	78	12	7	16,404	6,222
April	5,859	1.7	80	1	4	16,363	5,266	6,507	1.8	71	--	--	18,088	4,894
May	5,098	1.4	106	1	4	17,132	4,432	5,093	1.3	71	6	8	19,148	4,102
June	4,897	1.4	97	--	11	18,640	3,475	4,486	1.1	47	8	--	20,160	3,529
July	5,571	1.5	109	41	19	21,481	2,861	4,874	1.2	49	--	4	20,477	4,602
August	5,757	1.5	97	28	8	22,060	5,295	5,392	1.3	51	224	8	21,590	4,546
September	6,648	1.8	73	83	4	22,917	5,943	5,849	1.6	51	156	7	22,105	5,534
October	6,294	1.7	71	45	6	21,956	7,365	6,963	1.7	51	--	7	23,549	5,563
November	7,772	2.1	70	116	9	21,351	8,554	6,553	1.7	48	245	24	21,203	9,168
December	8,879	2.3	74	186	7	19,111	11,372	7,038	1.8	46	124	3	21,022	7,386
Total	79.027	1.8	1.063	526	91	19,111	85,852	79,422	1.7	704	785	85	21,022	78,915
By refining district:														
East Coast	6,190	1.3	--	524	9	7,231	43,759	5,079	1.0	--	785	4	7,877	32,853
Appalachian No. 1	1,614	2.7	--			476		1,930	3.0	--			624	
Appalachian No. 2	781	4.0	--		1	529		814	4.1	--			371	
Indiana, Illinois, Kentucky, etc	15,041	1.9	--	2		3,885	25,002	15,743	1.9	--			4,201	23,577
Minnesota, Wisconsin, etc	1,339	1.6	--			970		1,242	1.4	--	--	--	644	
Oklahoma, Kansas, etc	2,932	.9	--			646		2,088	.7	--			998	
Texas Inland	1,296	.9	368			195		1,130	.7	356			285	
Texas Gulf Coast	28,865	3.1	33			2,260		26,883	2.8	41			1,912	
Louisiana Gulf Coast	16,754	2.9	227	--	68	1,505	13,434	20,074	3.2	138		65	2,558	19,224
Arkansas, Louisiana Inland, etc	744	1.5	393			718		785	1.6	123			637	
New Mexico	103	.6	42			28		131	.8	46			20	
Rocky Mountain	1,844	1.3	--	--	--	297	2,062	2,204	1.4	--	--	--	477	1,985
West Coast	1,524	.2	--	--	13	371	1,595	1,319	.2	--	--	16	418	1,276
Total	79,027	1.8	1,063	526	91	19,111	85,852	79,422	1.7	704	785	85	21,022	78,915

p Preliminary.

Table 41.—Salient statistics of distillate fuel oil in the United States, by month and refining district

(Thousand barrels unless otherwise stated)

	1972								1973 p							
	Production at refineries	Yield (percent)	Production at gas processing plants	Crude used directly as distillate [1]	Imports	Exports	Total stocks, end of period	Domestic demand	Production at refineries	Yield (percent)	Production at gas processing plants	Crude used directly as distillate [1]	Imports	Exports	Total stocks, end of period	Domestic demand
By month:																
January	78,674	22.1	108	72	6,106	96	160,073	115,413	93,862	24.2	97	44	11,154	333	130,993	128,150
February	76,928	22.8	98	60	5,930	138	122,194	120,757	82,242	23.9	73	42	18,817	67	113,310	118,790
March	79,480	22.6	107	46	7,971	92	101,765	107,941	82,679	22.2	85	76	17,953	72	111,299	102,732
April	74,291	22.2	107	68	5,662	237	98,324	83,332	75,306	20.7	76	69	7,211	198	114,723	79,040
May	80,145	22.5	107	81	4,086	53	112,926	69,764	78,860	20.5	85	67	7,666	54	119,131	82,216
June	78,692	22.2	112	88	2,883	105	128,779	65,817	84,759	21.6	64	68	6,461	254	137,869	72,360
July	78,394	20.8	101	91	3,018	64	155,593	54,726	85,299	21.3	62	81	9,880	106	160,901	72,184
August	80,051	21.2	104	92	2,862	20	174,702	63,980	86,840	21.7	56	64	8,876	265	177,304	79,168
September	78,712	21.5	99	89	2,963	116	190,289	66,160	84,379	22.3	60	69	8,945	763	190,209	79,785
October	84,369	22.5	95	66	6,299	12	195,570	85,536	90,230	22.6	62	76	13,531	722	203,000	90,386
November	81,584	22.6	86	105	6,820	46	182,619	101,500	87,672	23.4	58	46	14,794	97	200,218	105,255
December	91,085	23.6	96	86	11,849	232	[2] 154,319	131,184	97,215	25.2	57	58	13,464	309	[2] 196,461	114,242
Total	962,405	22.2	1,220	944	66,449	1,211	[2] 154,319	1,066,110	1,029,343	22.5	835	760	138,752	3,240	[2] 196,461	1,124,308
By refining district:																
East Coast	118,572	24.6	--	--	64,302	95	61,513	511,291	130,868	25.0	--	--	121,598	207	75,359	520,668
Appalachian No. 1	13,916	23.6	--				3,297		16,135	25.2	--				4,119	
Appalachian No. 2	5,038	25.7	--				2,921		4,674	23.3	--				2,751	
Indiana, Illinois, Kentucky, etc	168,356	21.6	--	329	473	27	22,096	323,243	182,761	22.0	--	283	1,302	9	32,281	331,903
Minnesota, Wisconsin, etc	22,781	27.4	--				6,388		24,612	27.9	--				8,675	
Oklahoma, Kansas, etc	79,897	24.1	--				11,034		85,749	25.6					17,477	
Texas Inland	28,535	18.8	111				2,347		31,189	20.1	98				3,401	
Texas Gulf Coast	233,079	24.9	93				19,105		244,178	24.5	76				19,299	
Louisiana Gulf Coast	147,767	25.1	481	191	1,191	211	6,376	101,647	149,311	24.0	518	191	12,161	2,143	9,994	123,762
Arkansas, Louisiana Inland, etc	11,498	23.5	535				3,275		11,700	23.4	143				4,854	
New Mexico	3,299	20.3	--				281		3,601	21.2	--				276	
Rocky Mountain	38,024	26.3	--	69	--	--	2,558	30,445	41,966	27.7	--	69	89	--	4,150	34,782
West Coast	91,643	13.2	--	355	483	878	13,128	99,484	102,599	14.0	--	217	3,602	881	13,825	113,193
Total	962,405	22.2	1,220	944	66,449	1,211	[2] 154,319	1,066,110	1,029,343	22.5	835	760	138,752	3,240	[2] 196,461	1,124,308

p Preliminary.

[1] Figures represent crude oil used as fuel on pipelines which is considered part of the demand for distillate.

[2] Includes No. 4 fuel oil in thousands of barrels: PAD district I, 1972, 2,996; 1973, 3,068; PAD district II, 1972, 336; 1973, 129; PAD district III, 1972, 223; 1973, 170; PAD district IV, 1972, 12; 1973, 15; PAD district V, 1972, 156; 1973, 67.

Table 42.—Salient statistics of residual fuel oil in the United States, by month and refining district

(Thousand barrels unless otherwise stated)

	1972							1973 p						
	Production	Yield (percent)	Crude used directly as residual [1]	Imports	Exports	Stocks (end of period)	Domestic demand	Production	Yield (percent)	Crude used directly as residual [1]	Imports	Exports	Stocks (end of period)	Domestic demand
By month:														
January	28,646	8.0	277	58,658	547	59,440	87,275	34,472	8.9	330	61,290	1,031	49,154	101,123
February	27,929	8.3	262	55,761	548	50,891	91,953	29,053	8.5	312	58,025	948	43,058	92,538
March	25,662	7.3	252	59,718	1,806	51,566	83,151	29,592	8.0	329	67,742	801	44,711	95,209
April	22,169	6.6	243	50,265	1,507	49,425	73,311	26,315	7.2	326	51,089	1,233	47,044	74,164
May	20,591	5.8	255	48,770	567	53,035	65,439	29,392	7.6	320	51,657	1,152	49,207	78,054
June	19,820	5.6	275	49,455	603	56,109	65,873	27,448	7.0	729	52,716	243	51,811	78,046
July	20,863	5.5	268	49,416	1,099	60,230	65,327	27,352	6.8	492	49,515	1,107	53,363	74,700
August	20,882	5.5	272	51,244	1,259	61,399	69,970	26,368	6.6	813	57,346	912	53,586	83,392
September	21,295	5.8	279	48,736	856	63,692	67,161	26,338	7.0	568	55,248	653	55,091	79,996
October	23,092	6.2	309	51,303	1,428	63,758	73,210	30,517	7.7	722	48,235	645	54,964	78,956
November	26,711	7.4	314	53,075	873	57,702	85,283	31,840	8.5	690	58,248	205	51,985	93,552
December	34,859	9.0	316	61,000	967	55,216	97,694	35,910	9.3	495	55,595	301	53,480	90,204
Total	[2]292,519	6.8	3,322	[3]637,401	12,060	55,216	925,647	[2]354,597	7.7	6,126	[3]666,706	9,231	53,480	1,019,934
By refining district:														
East Coast	30,873	6.4	--	[4]616,990	1,502	23,622	686,554	45,238	8.7	--	[5]633,168	87	24,782	700,170
Appalachian No. 1	6,709	11.4				676		7,020	11.0				636	
Appalachian No. 2	1,730	8.8				305		1,758	8.8				316	
Indiana, Illinois, Kentucky, etc	50,219	6.4	578	[4]5,458	511	5,825	80,084	53,612	6.5	578	[5]6,107	179	5,668	86,052
Minnesota, Wisconsin, etc	7,016	8.4				1,002		8,026	9.1				1,162	
Oklahoma, Kansas, etc	6,883	2.1				935		7,724	2.3				1,147	
Texas Inland	3,608	2.4				310		5,695	3.7				355	
Texas Gulf Coast	37,682	4.0	1,781	6,212	4,667	3,893	31,757	53,075	5.4	1,784	10,102	2,289	3,912	70,549
Louisiana Gulf Coast	18,695	3.2				1,646		23,755	3.8				2,471	
Arkansas, Louisiana Inland, etc	4,428	9.1				205		4,764	9.6				237	
New Mexico	634	3.9				10		1,166	6.9				91	
Rocky Mountain	9,152	6.3	252	--	--	386	9,622	9,864	6.5	252	1	--	881	9,457
West Coast	114,890	16.6	711	8,741	5,380	16,401	117,630	132,900	18.1	3,512	[5]17,328	6,676	11,822	153,706
Total	[2]292,519	6.8	3,322	[3]637,401	12,060	55,216	925,647	[2]354,597	7.7	6,126	[3]666,706	9,231	53,480	1,019,934

p Preliminary.
[1] Represents crude oil used on leases and for general industrial purposes.
[2] Sulfur content in thousands of barrels: 0.50%, 1972; 64,855; 1973: 96,690, 0.51-1.00%, 1972; 70,824; 1973: 82,500, 1.01-2.00%, 1972: 92,652; 1973: 102,842, over 2.00%, 1972: 64,188; 1973: 72,565.
[3] Sulfur content in thousands of barrels: 0.50%, 1972: 203,137; 1973: 244,286, 0.51-1.00%, 1972: 163,764; 1973: 134,557, 1.01-2.00%, 1972: 79,316, 1973: 78,680, over 2.00%, 1972: 191,184; 1973: 163,213.
[4] Includes foreign crude oil to be burned as fuel, in thousands of barrels. Distrct I: 9,939; District II: 480.
[5] Includes foreign crude oil to be burned as fuel, in thousands of barrels. District I: 13,153; District II: 1,916; District V: 4,036.

Table 43.—Salient statistics of jet fuel in the United States, by month and refining district

(Thousand barrels)

1972	Production			Imports			Exports			Total stocks, end of period			Domestic demand		
	Naphtha type	Kerosine type	Total	Naphtha type	Kerosine type	Total	Naphtha type	Kerosine type	Total	Naphtha type [1]	Kerosine type	Total	Naphtha type	Kerosine type	Total
By month:															
January	5,696	18,618	24,314	836	4,705	5,541	99	--	99	6,658	19,199	25,857	6,765	24,871	31,636
February	6,596	19,498	26,094	610	5,778	6,388	18	10	28	6,339	18,891	25,230	7,507	25,574	33,081
March	6,921	21,178	28,099	391	4,776	5,167	104	--	104	6,966	20,181	27,147	6,581	24,664	31,245
April	7,020	19,275	26,295	444	3,270	3,714	15	--	15	6,471	21,097	27,568	7,944	21,629	29,573
May	6,873	20,638	27,511	1,123	3,812	4,935	145	--	145	6,093	22,792	28,885	8,229	22,755	30,984
June	6,825	18,940	25,765	1,121	7,636	8,757	152	--	152	5,889	22,467	28,356	7,998	26,901	34,899
July	6,416	20,660	27,076	825	4,286	5,111	127	--	127	5,844	23,585	29,429	7,159	23,828	30,987
August	6,793	19,162	25,955	730	4,882	5,612	15	--	15	6,517	25,132	31,649	6,835	22,497	29,332
September	5,833	18,478	24,311	894	4,796	5,690	16	--	16	6,149	24,448	30,597	7,079	23,958	31,037
October	6,077	19,407	25,484	1,657	7,220	8,877	16	--	16	5,933	22,700	28,633	7,934	28,375	36,309
November	5,742	18,247	23,989	1,835	3,699	5,534	17	--	17	5,647	21,003	26,650	7,846	23,643	31,489
December	5,773	19,363	25,136	1,532	4.316	5,848	187	36	223	6,147	19,346	25,493	6,618	25,300	31,918
Total	76,565	233,464	310,029	11,998	59,176	71,174	911	46	957	6,147	19,346	25,493	88,495	293,995	382,490
By refining district:															
East Coast	1,454	10,545	11,999	8,336	30,294	38,630	--	--	--	377	3,651	4,028	23,375	121,449	144,824
Appalachian No. 1	650	678	1,328							55	256	311			
Appalachian No. 2	--	--	--	--	2,789	2,789	--	--	--	51	196	247	16,510	60,838	77,348
Indiana, Illinois, Kentucky, etc	7,552	35,421	42,973							659	3,238	3,897			
Minnesota, Wisconsin, North Dakota, South Dakota	1,446	1,397	2,843							152	795	947			
Oklahoma, Kansas, Missouri, etc	6,686	10,404	17,090							771	957	1,728			
Texas Inland	5,084	9,040	14,124	--	4,451	4,451	1	10	11	314	1,234	1,548	15,063	18,383	33,446
Texas Gulf Coast	12,487	53,702	66,189							925	2,213	3,138			
Louisiana Gulf Coast	7,692	47,540	55,232							512	1,149	1,661			
Arkansas, Louisiana Inland, etc	1,553	8	1,561							285	419	704			
New Mexico	2,073	50	2,123							184	42	226			
Rocky Mountain	4,079	4,513	8,592	--	--	--	--	--	--	284	338	622	2,476	7,329	9,805
West Coast	25,809	60,166	85.975	3,662	21.642	25,304	910	36	946	1,578	4,858	6,436	31,071	85,996	117,067
Total	76,565	233,464	310,029	11,998	59,176	71,174	911	46	957	6,147	19,346	25,493	88,495	293,995	382,490

1973 p															
By month:															
January	5,281	21,506	26,787	777	6,380	7,157	180	34	214	5,953	18,861	24,814	6,072	28,337	34,409
February	4,589	20,567	25,156	440	5,759	6,199	184	21	205	5,486	19,951	25,437	5,312	25,215	30,527
March	6,057	22,369	28,426	394	4,330	4,724	169	29	198	5,899	21,686	27,585	5,869	24,935	30,804
April	5,955	20,658	26,613	846	3,507	4,353	54	172	226	5,209	22,672	27,881	7,437	23,007	30,444
May	6,005	20,031	26,036	681	5,846	6,527	22	112	134	5,055	20,770	25,825	6,818	27,667	34,485
June	5,344	19,731	25,075	926	3,961	4,887	11	128	139	4,603	20,844	25,447	6,711	23,490	30,201
July	4,833	20,739	25,572	981	6,166	7,147	3	105	108	4,280	21,381	25,661	6,134	26,263	32,397
August	5,371	20,802	26,173	1,858	3,715	5,573	--	32	32	4,268	20,583	24,851	7,241	25,283	32,524
September	5,578	19,841	25,419	1,219	5,658	6,877	--	58	58	4,652	20,497	25,149	6,413	25,527	31,940
October	5,278	21,851	27,129	2,218	4,232	6,450	1	100	101	4,242	21,335	25,577	7,905	25,145	33,050
November	4,905	20,668	25,573	1,695	6,190	7,885	11	92	103	4,939	23,600	28,539	5,892	24,501	30,393
December	6,801	18,929	25,730	1,280	5,226	6,506	5	45	50	5,599	22,945	28,544	7.416	24,765	32,181
Total	65,997	247,692	313,689	13,315	60,970	74,285	640	928	1,568	5,599	22,945	28,544	79,220	304,135	383,355
By refining district:															
East Coast	1,907	11,223	13,130	10,000	32,522	42,522	2	2	4	188	5,027	5,215	22,552	127,404	149,956
Appalachian No. 1	819	695	1,514							105	208	313			
Appalachian No. 2	--	--	--							9	206	215			
Indiana, Illinois, Kentucky, etc	5,738	38,671	44,409							362	3,840	4,202			
Minnesota, Wisconsin, North Dakota, South Dakota	981	1,490	2,471	--	2,450	2,450	--	--	--	153	705	858	13,180	61,632	74,812
Oklahoma, Kansas, Missouri, etc	5,218	10,627	15,845							690	1,275	1,965			
Texas Inland	5,579	8,004	13,583							363	1,069	1,432			
Texas Gulf Coast	10,775	56,473	67,248							932	3,245	4,177			
Louisiana Gulf Coast	7,677	49,630	57,307	--	5,902	5,902	1	--	1	569	1,348	1,917	16,693	19,504	36,197
Arkansas, Louisiana Inland, etc	1,610	1	1,611							172	438	610			
New Mexico	2,052	65	2,117							218	78	296			
Rocky Mountain	3,493	4,611	8,104	--	--	--	--	--	--	230	385	615	2,878	8,320	11,198
West Coast	20,148	66,202	86,350	3,315	20,096	23,411	637	926	1,563	1,608	5,121	6,729	23,917	87,275	111,192
Total	65,997	247,692	313,689	13,315	60,970	74,285	640	928	1,568	5,599	22,945	28,544	79,220	304,135	383,355

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1 Includes naphtha type jet fuel stored at natural gas processing plants: Arkansas, Louisiana Inland, etc., 1972, 2; 1973, none.

Table 44.—Salient statistics of lubricants in the United States, by month and refining district

(Thousand barrels unless otherwise stated)

	Production				Yield (percent)	Imports (all types)	Exports (all types)	Stocks, end of period				Domestic demand (all types)
	Bright stock	Neutral	Other grades	Total				Bright stock	Neutral	Other grades	Total	
1972												
By month:												
January	614	2,402	2,451	5,467	1.5	1	1,457	1,423	5,011	8,891	15,325	3,735
February	584	2,159	2,184	4,927	1.5	1	975	1,462	4,877	8,797	15,136	4,142
March	559	2,381	2,456	5,396	1.5	--	1,509	1,315	4,506	8,608	14,429	4,594
April	463	2,452	2,280	5,195	1.6	2	1,353	1,273	4,446	8,003	13,722	4,551
May	542	2,611	2,543	5,696	1.6	1	1,156	1,216	4,592	7,921	13,729	4,534
June	511	2,643	2,440	5,594	1.6	1	1,114	1,157	4,520	8,218	13,895	4,315
July	554	2,378	2,466	5,398	1.4	112	1,129	1,092	4,379	7,955	13,426	4,850
August	530	2,729	2,526	5,785	1.5	63	1,244	1,054	4,351	7,878	13,283	4,747
September	492	2,329	2,516	5,337	1.5	78	1,117	1,044	4,351	7,883	13,278	4,303
October	563	2,433	2,631	5,627	1.5	122	1,173	1,031	4,147	8,071	13,249	4,605
November	572	2,381	2,438	5,391	1.5	170	1,383	1,088	3,772	7,996	12,856	4,571
December	556	2,365	2,615	5,536	1.4	118	1,373	1,099	3,857	8,315	13,271	3,866
Total	6,540	29,263	29,546	65,349	1.5	669	14,983	1,099	3,857	8,315	13,271	52,813
By refining district:												
East Coast	356	2,903	3,606	6,865	1.4	661	3,452	39	426	2,382	2,847	20,951
Appalachian No. 1	1,301	2,439	389	4,129	7.0			205	273	568	1,046	
Appalachian No. 2	--	12	--	12	--			--	--	294	294	
Indiana, Illinois, Kentucky, etc	498	3,260	1,498	5,256	.7	5	457	103	587	774	1,464	13,426
Minnesota, Wisconsin, etc	--	--	--	--	--			--	--	34	34	
Oklahoma, Kansas, etc	654	3,180	1,418	5,252	1.6			181	404	139	724	
Texas Inland	--	--	98	98	.1			--	--	37	37	
Texas Gulf Coast	1,512	8,440	18,024	27,976	3.0			249	1,054	2,499	3,802	
Louisiana Gulf Coast	751	5,645	1,298	7,694	1.3	--	9,716	49	586	277	912	11,585
Arkansas, Louisiana Inland, etc	--	887	1,169	2,056	4.2			--	63	271	334	
New Mexico	--	--	--	--	--			--	--	9	9	
Rocky Mountain	57	195	143	395	.3	--	5	11	74	12	97	871
West Coast	1,411	2,302	1,903	5,616	.8	3	1,353	262	390	1,019	1,671	5,980
Total	6,540	29,263	29,546	65,349	1.5	669	14,983	1,099	3,857	8,315	13,271	52,813

1973 p												
By month:												
January	572	2,772	2,396	5,740	1.5	210	1,215	1,110	4,179	8,108	13,397	4,609
February	520	2,349	2,546	5,415	1.6	160	1,075	1,064	4,262	8,015	13,341	4,556
March	703	2,611	2,555	5,869	1.6	230	1,250	1,164	4,377	7,738	13,279	4,911
April	652	2,376	2,457	5,485	1.5	205	1,175	1,187	4,470	7,784	13,441	4,353
May	609	2,380	2,783	5,772	1.5	35	1,196	1,068	4,242	7,600	12,910	5,142
June	558	2,375	2,477	5,410	1.4	119	1,196	1,058	4,101	7,611	12,770	4,473
July	705	2,338	2,749	5,792	1.4	121	1,050	1,053	3,880	7,276	12,209	5,424
August	571	2,495	2,534	5,600	1.4	217	982	935	3,731	7,099	11,765	5,279
September	546	2,348	2,566	5,460	1.4	170	967	878	3,816	7,111	11,805	4,623
October	669	2,621	2,881	6,171	1.6	113	773	955	3,659	7,009	11,623	5,693
November	606	2,624	2,792	6,022	1.6	333	875	964	4,034	7,059	12,057	5,046
December	770	2,675	2,561	6,006	1.6	119	1,068	1,098	4,186	6,902	12,186	4,928
Total	7,481	29,964	31,297	68,742	1.5	2,032	12,822	1,098	4,186	6,902	12,186	59,037
By refining district:												
East Coast	599	3,302	3,711	7,612	1.5	1,980	3,489	75	648	1,803	2,526	23,923
Appalachian No. 1	1,396	2,727	346	4,469	6.9			270	291	487	1,048	
Appalachian No. 2	--	--	--	--	--			--	--	43	43	
Indiana, Illinois, Kentucky, etc	438	3,258	1,684	5,380	.6	1	476	69	579	787	1,435	14,281
Minnesota, Wisconsin, etc	--	--	--	--	--			--	--	34	34	
Oklahoma, Kansas, etc	1,126	2,705	1,514	5,345	1.6			173	357	135	665	
Texas Inland	--	--	108	108	.1			--	--	28	28	
Texas Gulf Coast	1,932	8,577	19,612	30,121	3.0			266	1,084	2,521	3,871	
Louisiana Gulf Coast	662	6,039	1,185	7,886	1.3	51	7,723	60	821	225	1,106	14,639
Arkansas, Louisiana Inland, etc	--	851	1,133	1,984	3.9			--	46	174	220	
New Mexico	--	--	--	--	--			--	--	4	4	
Rocky Mountain	44	176	167	387	.3	--	11	7	74	30	111	48
West Coast	1,284	2,329	1,837	5,450	.7	--	1,123	178	286	631	1,095	6,146
Total	7,481	29,964	31,297	68,742	1.5	2,032	12,822	1,098	4,186	6,902	12,186	59,037

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Table 45.—Salient statistics of liquefied gases (excluding ethane) in the United States, by month and refining district

(Thousand barrels unless otherwise stated)

	1972								1973 p							
	Refinery production	Yield (percent)	Production at gas processing plants	Imports	Exports	LPG used at refineries	Total stocks, end of period	Domestic demand	Refinery production	Yield (percent)	Production at gas processing plants	Imports	Exports	LPG used at refineries	Total stocks, end of period	Domestic demand
By month:																
January	9,690	2.7	29,666	4,331	891	9,243	79,161	45,740	10,466	2.8	28,377	6,315	893	8,666	62,083	52,181
February	9,576	2.8	27,882	3,520	878	8,450	68,206	42,605	9,400	2.7	26,980	5,317	1,139	6,982	52,756	42,903
March	10,329	2.9	29,678	3,556	1,106	7,196	68,575	34,892	10,988	2.9	28,925	4,558	1,109	6,377	56,584	33,157
April	10,048	3.0	29,124	1.778	779	6,062	75,362	27,322	10,503	2.9	28,924	2,689	797	5,238	63,572	29,093
May	10,555	3.0	28,917	1,856	836	5,853	87,601	22,400	12,147	3.2	29,317	3,511	777	5,285	73,062	29,423
June	10,121	2.9	27,628	1,610	807	5,298	95,787	25,068	10,795	2.8	28,163	2,273	705	5,494	83,315	24,779
July	10,761	2.9	28,127	1,598	848	5,734	104,150	25,541	11,869	2.9	27,720	2,683	788	5,934	94,296	24,569
August	10,671	2.8	28,276	1,780	1,012	5,554	109,003	29,308	11,193	2.8	27,649	3,843	820	6,617	100,476	29,068
September	10,045	2.7	27,447	2,019	941	6,046	113,265	28,262	10,373	2.7	27,361	2,961	766	6,254	105,067	29,084
October	9,885	2.6	29,316	3,294	1,083	7,858	109,323	37,496	10,968	2.7	28,661	4,610	758	7,483	105,116	35,949
November	9,359	2.6	28,881	3,283	1,065	9,187	96,448	44,146	9,176	2.5	27,985	5,098	683	7,853	98,834	40,005
December	10,142	2.6	29,103	3,776	1,223	8,712	78,665	50,869	9,754	2.5	28,751	3,943	721	8,038	93,618	38,905
Total	121,182	2.8	344,045	32,401	11,469	85,193	78,665	413,649	127,632	2.8	338,813	47,801	9,956	80,221	93,618	409,116
By refining district:																
East Coast	16,488	3.4	4,786	5,336	39	251	4,831	57,076	19,346	3.7	5,756	8,549	37	148	5,590	65,292
Appalachian No. 1	1,432	2.4				90			1,412	2.2				127		
Appalachian No. 2	324	1.6							367	1.8						
Indiana, Illinois, Kentucky, etc	17,034	2.2	56,319	14,441	96	11,750	25,716	126,872	19,209	2.3	54,787	18,417	324	11,948	32,976	125,661
Minnesota, Wisconsin, etc	1,506	1.8				3,415			1,522	1.7				2,973		
Oklahoma, Kansas, etc	8,279	2.5				11,107			8,473	2.5				11,784		
Texas Inland	3,578	2.4				8,764			3,399	2.2				7,052		
Texas Gulf Coast	30,945	3.3				18,418			32,800	3.3				13,954		
Louisiana Gulf Coast	21,411	3.6	265,505	787	9,839	19,037	46,850	192,529	21,134	3.4	261,535	9,116	7,868	19,864	52,905	186,841
Arkansas, Louisiana Inland, etc	948	1.9				1,168			1,024	2.0				1,093		
New Mexico	459	2.8				672			369	2.2				615		
Rocky Mountain	2,248	1.6	11,584	5,405	--	3,272	386	15,012	2,236	1.5	11,406	5,496	1	3,443	664	10,389
West Coast	16,530	2.4	5,851	6,432	1,495	7,249	882	22,160	16,341	2.3	5,329	6,223	1,726	7,220	1,483	20,933
Total	121,182	2.8	344,045	32,401	11,469	85,193	78,665	413,649	127,632	2.8	338,813	47,801	9,956	80,221	93,618	409,116

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Table 46.—Salient statistics of ethane (including ethylene) in the United States, by month and refining district

(Thousand barrels)

	1972					1973 p				
	Production			Total stocks (end of period)	Domestic demand	Production			Total stocks (end of period)	Domestic demand
	At gas processing plants	At refineries	Total			At gas processing plants	At refineries	Total		
By month:										
January	7,467	820	8,287	3,265	8,387	8,999	722	9,721	7,139	9,634
February	7,788	824	8,612	3,677	8,200	8,417	659	9,076	7,126	9,089
March	8,633	821	9,454	4,112	9,019	9,725	736	10,461	7,173	10,414
April	7,802	786	8,588	4,589	8,111	8,805	687	9,492	6,869	9,796
May	8,274	737	9,011	5,127	8,473	9,097	892	9,989	6,976	9,882
June	7,958	715	8,673	5,423	8,377	8,602	849	9,451	6,733	9,694
July	8,680	783	9,463	5,690	9,196	8,792	842	9,634	6,734	9,633
August	8,687	757	9,444	5,888	9,246	8,966	898	9,864	6,374	10,224
September	8,535	723	9,258	6,086	9,060	8,670	717	9,387	6,193	9,568
October	9,060	811	9,871	6,170	9,787	9,316	713	10,029	6,139	10,083
November	8,720	718	9,438	6,719	8,889	9,272	759	10,031	5,381	10,789
December	9,087	702	9,789	7,052	9,456	9,559	720	10,279	5,023	10,637
Total	100,691	9,197	109,888	7,052	106,201	108,220	9,194	117,414	5,023	119,443
By refining district:										
East Coast	--	--	--			--	58	58		
Appalachian No. 1	1,712	--	1,712	--	1,712	1,721	--	1,721	--	1,779
Appalachian No. 2	--	--	--			--	--	--		
Indiana, Illinois, Kentucky, etc	7,232	--	7,232	986	11,308	7,451	--	7,451	1,225	13,399
Minnesota, Wisconsin, etc	--	--	--			--	--	--		
Oklahoma, Kansas, etc	3,537	590	4,127			5,667	520	6,187		
Texas Inland	40,260	104	40,364			40,158	108	40,266		
Texas Gulf Coast	16,520	4,802	21,322			16,475	5,040	21,515		
Louisiana Gulf Coast	27,538	3,147	30,685	6,064	92,588	31,191	2,960	34,151	3,795	103,713
Arkansas, Louisiana Inland, etc	817	--	817			1,229	--	1,229		
New Mexico	3,035	--	3,035			4,283	--	4,283		
Rocky Mountain	40	3	43	2	42	45	--	45	3	44
West Coast	--	551	551	--	551	--	508	508	--	508
Total	100,691	9,197	109,888	7,052	106,201	108,220	9,194	117,414	5,023	119,443

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Table 47.—Salient statistics on petrochemical feedstocks[1] in the United States, by month and refining district

(Thousand barrels)

	Production				Imports	Exports (other)	Stocks, end of period			Domestic demand (all types)
	Still gas	Naphtha 400°	Other	Total			Naphtha 400°	Other	Total	
1972										
By month:										
January	1,230	4,646	3,920	9,796	130	580	1,360	1,876	3,236	9,996
February	1,055	4,390	4,057	9,502	181	384	1,200	1,915	3,115	9,420
March	1,033	4,380	3,907	9,320	389	374	1,199	1,602	2,801	9,649
April	935	5,005	4,742	10,682	21	309	1,213	1,881	3,094	10,101
May	1,095	4,723	4,164	9,982	581	297	1,138	1,714	2,852	10,508
June	1,147	4,866	3,567	9,580	210	430	1,130	1,701	2,831	9,381
July	1,378	4,685	4,253	10,316	274	418	1,035	1,692	2,727	10,276
August	1,444	5,041	4,499	10,984	301	388	1,190	1,634	2,824	10,800
September	1,144	4,303	4,751	10,198	332	99	1,096	1,653	2,749	10,506
October	1,500	4,575	4,972	11,047	340	134	910	1,445	2,355	11,647
November	1,360	4,957	4,729	11,046	87	824	1,120	1,601	2,721	9,943
December	1,357	5,456	4,760	11,573	332	390	982	1,784	2,766	11,470
Total	14,678	57,027	52,321	124,026	3,178	4,627	982	1,784	2,766	123,697
By refining district:										
East Coast	945	5,392	66	6,403	--	710	--	--	--	9,163
Appalachian No. 1	74	--	665	739			--	13	13	
Appalachian No. 2	--	--	--	--			--	--	--	
Indiana, Illinois, Kentucky, etc	2,610	4,241	2,293	9,144			101	152	253	15,991
Minnesota, Wisconsin, etc	--	--	--	--	--	47	--	--	--	
Oklahoma, Kansas, etc	2,070	2,147	451	4,668			85	74	159	
Texas Inland	274	1,461	3,469	5,204			1	249	250	
Texas Gulf Coast	7,647	38,732	20,063	66,442			687	526	1,213	
Louisiana Gulf Coast	79	337	21,882	22,298	3,178	1,677	--	437	437	91,673
Arkansas, Louisiana Inland, etc	5	--	225	230			--	4	4	
New Mexico	12	--	--	12			--	--	--	
Rocky Mountain	226	--	79	305	--	13	--	1	1	333
West Coast	736	4,717	3,128	8,581	--	2,180	108	328	436	6,537
Total	14,678	57,027	52,321	124,026	3,178	4,627	982	1,784	2,766	123,697

1973p										
By month:										
January	1,327	4,780	4,821	10,928	318	149	964	1,654	2,618	11,245
February	840	4,751	4,495	10,086	580	634	1,065	1,783	2,848	9,802
March	1,183	4,509	5,270	10,962	191	184	1,253	1,804	3,057	10,760
April	1,019	4,815	5,337	11,171	324	251	1,396	1,633	3,029	11,272
May	1,222	3,943	5,040	10,205	216	390	1,128	1,609	2,737	10,323
June	1,054	4,329	5,572	10,955	358	588	1,077	1,782	2,859	10,603
July	916	4,655	5,468	11,039	214	576	954	1,684	2,638	10,898
August	1,188	4,648	5,351	11,187	429	588	851	1,509	2,360	11,306
September	1,015	4,816	4,998	10,829	171	365	908	1,348	2,256	10,739
October	884	5,106	5,620	11,610	331	752	1,059	1,561	2,620	10,825
November	902	5,066	5,548	11,516	279	630	918	1,524	2,442	11,343
December	878	5,737	5,461	12,076	414	694	1,012	1,375	2,387	11,851
Total	12,428	57,155	62,981	132,564	3,825	5,801	1,012	1,375	2,387	130,967
By refining district:										
East Coast	919	4,932	30	5,881	359	602	--	--	--	9,626
Appalachian No. 1	23	--	738	761			--	12	12	
Appalachian No. 2	--	--	--	--			--	--	--	
Indiana, Illinois, Kentucky, etc	2,128	4,373	2,304	8,805	--	64	187	116	303	13,847
Minnesota, Wisconsin, etc	--	--	--	--			--	--	--	
Oklahoma, Kansas, etc	543	2,200	553	3,296			65	106	171	
Texas Inland	432	1,768	3,578	5,778			1	182	183	
Texas Gulf Coast	7,341	38,041	26,135	71,517			692	453	1,145	
Louisiana Gulf Coast	--	489	26,236	26,725	3,466	2,761	1	257	258	100,178
Arkansas, Louisiana Inland, etc	--	--	241	241			--	4	4	
New Mexico	--	--	--	--			--	--	--	
Rocky Mountain	161	--	34	195	--	18	--	--	--	216
West Coast	881	5,352	3,132	9,365	--	2,356	66	245	311	7,100
Total	12,428	57,155	62,981	132,564	3,825	5,801	1,012	1,375	2,387	130,967

p Preliminary.
1 Produced at petroleum refineries (excluding ethane and liquefied gases).

Table 48.—Statistical summary of petroleum asphalt and road oil

(Thousand short tons) [1]

	1969	1970	1971	1972	1973 p
Petroleum asphalt:					
Production	24,671	26,665	28,553	28,235	30,524
Imports (including natural)	866	1,127	1,312	1,684	1,535
Exports	84	65	55	61	62
Stocks (end of period)	3,046	2,869	3,855	3,934	2,731
Apparent domestic consumption	26,053	27,905	28,823	29,779	33,200
Petroleum asphalt shipments:					
Paving	21,333	23,594	23,821	24,308	27,113
Roofing	4,080	4,248	4,362	5,347	5,677
All other	2,743	1,870	1,840	1,466	1,620
Total	28,156	29,712	30,023	31,121	34,410
Road oil:					
Production	1,652	1,708	1,592	1,444	1,332
Stocks (end of period)	160	115	164	237	145
Apparent domestic consumption	1,592	1,753	1,543	1,371	1,424
Road oil shipments	1,116	1,753	1,543	1,371	1,424

p Preliminary.
[1] Converted from barrels to short tons (5.5 barrels=1 short tons).

Table 49.—Salient statistics of petroleum asphalt in the United States, by month and refining district

(Thousand short tons) [1]

	1972					1973 p				
	Production	Imports (including natural)	Exports	Stocks (end of period)	Domestic demand	Production	Imports (including natural)	Exports	Stocks (end of period)	Domestic demand
By month:										
January	1,482	80	5	4,377	1,035	1,440	72	3	4,426	1,017
February	1,477	88	5	4,828	1,108	1,516	55	3	4,908	1,086
March	1,810	57	6	5,317	1,372	1,838	78	4	5,414	1,406
April	2,068	100	3	5,643	1,838	2,197	49	6	5,637	2,016
May	2,714	131	5	5,632	2,851	2,673	124	5	5,499	2,929
June	2,908	158	5	5,198	3,495	3,054	68	5	4,969	3,647
July	3,100	138	4	4,794	3,639	3,216	238	5	4,158	4,260
August	3,180	210	8	3,768	4,408	3,441	203	6	3,047	4,750
September	3,024	224	7	3,423	3,587	3,291	207	6	2,709	3,830
October	2,744	158	5	3,129	3,192	3,240	133	8	2,267	3,808
November	2,071	205	4	3,354	2,047	2,551	132	5	2,192	2,753
December	1,657	135	4	3.934	1.207	2.067	176	6	2,731	1,698
Total	28,235	1,684	61	3,934	29,779	30,524	1,535	62	2,731	33,200
By refining district										
East Coast	5,107	1,605	9	966	7,996	6,243	1,471	7	721	9,388
Appalachian No. 1	295			71		378			48	
Appalachian No. 2	263			96		307			66	
Illinois, Indiana, Kentucky, etc	5,725	10	8	697	10,227	6,084	14	7	415	11,673
Minnesota, Wisconsin, North Dakota	1,153			201		1,367			108	
Oklahoma, Kansas, etc	2,651			395		2,722			253	
Texas Inland	1,292			110		1,376			111	
Texas Gulf Coast	1,551			129		1,714			124	
Louisiana Gulf Coast	2,847	69	7	216	5,959	2,678	50	8	133	6,072
Arkansas, Louisiana Inland, etc	1,483			156		1,618			115	
New Mexico	185			63		147			20	
Rocky Mountain	1,884	--	3	357	2,086	1,888	--	1	231	2,230
West Coast	3,799	--	34	477	3,511	4,002	--	39	386	3,837
Total	28,235	1,684	61	3,934	29,779	30,524	1,535	62	2,731	33,200

p Preliminary.
[1] Converted from barrels to short tons (5.5 barrels=1 short tons).

Table 50.—Salient statistics of road oil in the United States, by month and refining district

(Short tons) [1]

	1972			1973 p		
	Production	Stocks (end of period)	Domestic demand	Production	Stocks (end of period)	Domestic demand
By month:						
January	52,364	185,636	30,364	34,909	253,818	18,364
February	64,727	234,727	15,636	34,909	272,000	16,727
March	115,455	318,545	31,636	86,546	323,818	34,727
April	111,454	369,091	60,909	100,909	380,727	44,000
May	139,636	354,545	154,182	120,364	366,182	134,909
June	207,091	371,273	190,364	190,182	329,818	226,546
July	209,273	335,636	244,909	181,636	279,091	232,364
August	209,273	302,364	242,545	203,091	202,182	280,000
September	152,000	265,455	188,909	161,818	188,182	175,818
October	108,182	233,454	140,182	123,273	157,455	154,000
November	49,636	230,909	52,182	55,454	131,455	81,454
December	25,091	237,273	18,727	38,909	145,273	25,091
Total	1,444,182	237,273	1,370,545	1,332,000	145,273	1,424,000
By refining district:						
East Coast	8,909	--	122,363	--	--	119,818
Appalachian No. 1	112,545	3,091		128,364	11,637	
Appalachian No. 2	--	--		--	--	
Indiana, Illinois, Kentucky, etc	497,273	62,182		514,182	23,273	
Minnesota, Wisconsin, North Dakota	37,636	727	700,182	--	--	787,636
Oklahoma, Kansas, etc	170,546	11,636		232,000	9,818	
Texas Inland	12,546	--		11,636	--	
Texas Gulf Coast	6,000	--		--	--	
Louisiana Gulf Coast	--	--	20,182	--	--	11,637
Arkansas, Louisiana Inland, etc	--	--		--	--	
New Mexico	--	--		--	--	
Rocky Mountain	208,000	13,455	249,636	140,000	3,818	354,000
West Coast	390,727	146,182	278,182	305,818	96,727	150,909
Total	1,444,182	237,273	1,370,545	1,332,000	145,273	1,424,000

p Preliminary.
[1] Converted from barrels to short tons (5.5 barrels = 1 short ton).

Table 51.—Salient statistics of special naphthas in the United States, by month and refining district

(Thousand barrels unless otherwise stated)

	1972							1973 p						
	Production at refineries	Yield (percent)	Production at gas processing plants	Imports	Exports	Total stocks (end of period) [1]	Domestic demand	Production at refineries	Yield (percent)	Production at gas processing plants	Imports	Exports	Total stocks (end of period) [1]	Domestic demand
By month:														
January	2,502	0.7	24	304	119	5,594	2,501	2,742	0.7	19	7	169	5,038	2,793
February	2,466	.7	20	24	72	5,575	2,457	2,320	.7	19	4	108	4,576	2,697
March	2,663	.8	24	7	172	4,903	3,194	2,802	.8	20	33	134	4,491	2,806
April	2,753	.8	22	52	98	5,231	2,401	2,499	.7	21	5	111	4,860	2,045
May	2,674	.8	22	4	156	5,087	2,688	2,697	.7	19	6	137	4,316	3,129
June	2,383	.7	21	4	99	4,585	2,811	2,673	.7	17	6	140	4,242	2,630
July	2,864	.8	22	24	227	4,842	2,426	3,126	.8	17	9	160	4,520	2,714
August	2,997	.8	22	160	118	4,958	2,945	2,867	.7	17	5	125	4,328	2,956
September	2,791	.8	20	5	117	5,025	2,632	2,720	.7	15	5	119	4,450	2,499
October	2,546	.7	23	256	115	4,818	2,917	2,977	.7	16	--	111	4,337	2,995
November	2,636	.7	21	4	94	5,132	2,253	2,628	.7	15	5	149	4,383	2,453
December	2,821	.7	23	19	122	5,232	2,641	2,822	.7	15	3	189	4,521	2,513
Total	32,096	.7	264	863	1,509	5,232	31,866	32,873	.7	210	88	1,652	4,521	32,230
By refining district:														
East Coast	200	--	--	508	291	1,169	7,785	123	--	--	6	400	873	7,477
Appalachian No. 1	339	.6	--			63		268	.5	--			73	
Appalachian No. 2	282	1.4	--			23		257	1.3	--			13	
Indiana, Illinois, Kentucky, etc	3,755	.5	--	49	162	761	8,297	4,563	.6	--	80	118	719	9,379
Minnesota, Wisconsin, etc	--	--	--			83		--	--	--			60	
Oklahoma, Kansas, etc	1,330	.4	13			157		1,286	.4	--			110	
Texas Inlnad	1,219	.8	--			115		1,425	.9	--			75	
Texas Gulf Coast	18,014	1.9	--			2,022		17,716	1.8	--			1,725	
Louisiana Gulf Coast	307	.1	--	250	909	55	10,404	266	--	--	--	1,050	41	10,138
Arkansas, Louisiana Inland, etc	1,269	2.6	251			153		1,603	3.2	210			157	
New Mexico	--	--	--			--		--	--	--			--	
Rocky Mountain	205	.1	--	56	12	35	273	125	--	--	2	--	39	149
West Coast	5,176	.7	--	--	135	596	5,107	5,241	.7	--	--	84	636	5,087
Total	32,096	.7	264	863	1,509	5,232	31,866	32,873	.7	210	88	1,652	4,521	32,230

p Preliminary.
[1] Includes inventories at natural gas processing plants: Arkansas, Louisiana Inland, etc., 1972, 8; 1973, 7.

Table 52.—Salient statistics of wax in the United States, by types, month, and refining district [1]

(Thousand barrels)

	Production				Imports (all types)	Exports (all types)	Stocks, end of period				Domestic demand (all types)
	Microcrystalline	Crystalline, fully-refined	Crystalline, other	Total			Microcrystalline	Crystalline, fully-refined	Crystalline, other	Total	
1972											
By month:											
January	65	250	197	512	13	122	227	422	472	1,121	399
February	101	265	128	494	2	98	241	480	376	1,097	422
March	101	335	135	571	3	165	243	515	348	1,106	400
April	69	232	170	471	4	88	220	482	365	1,067	426
May	68	260	220	548	2	130	190	459	375	1,024	463
June	80	241	173	494	3	67	188	435	347	970	484
July	81	253	183	517	58	90	204	462	365	1,031	424
August	79	278	170	527	29	90	197	438	358	993	504
September	82	244	188	514	46	63	207	432	375	1,014	476
October	74	273	162	509	38	55	202	449	387	1,038	468
November	78	260	166	504	78	94	200	447	389	1,036	490
December	77	276	134	487	59	68	201	469	391	1,061	453
Total	955	3,167	2,026	6,148	335	1,130	201	469	391	1,061	5,409
By refining district:											
East Coast	171	828	261	1,260	305	479	23	117	5	145	2,923
Appalachian No. 1	237	148	421	806			63	95	67	225	
Appalachian No. 2	--	--	--	--			--	--	--	--	
Indiana, Illinois, Kentucky, etc	9	205	192	406	5	35	2	10	118	130	969
Minnesota, Wisconsin, etc	--	--	--	--			--	--	--	--	
Oklahoma, Kansas, etc	265	246	104	615			43	18	13	74	
Texas Inland	69	--	--	69			20	--	--	20	
Texas Gulf Coast	141	611	834	1,586			21	42	156	219	
Louisiana Gulf Coast	53	509	64	626	25	558	25	137	1	163	780
Arkansas, Louisiana Inland, etc	--	--	--	--			--	--	--	--	
New Mexico	--	--	--	--			--	--	--	--	
Rocky Mountain	10	63	27	100	--	--	4	23	19	46	128
West Coast	--	557	123	680	--	58	--	27	12	39	609
Total	955	3,167	2,026	6,148	335	1,130	201	469	391	1,061	5,409

1973 p											
By month:											
January	78	280	178	536	100	121	183	478	397	1,058	518
February	66	189	159	414	61	60	175	405	409	989	484
March	81	231	222	534	103	88	154	362	431	947	591
April	83	254	176	513	94	85	157	375	474	1,006	463
May	87	298	188	573	71	87	147	373	397	917	646
June	115	250	174	539	90	73	150	377	393	920	553
July	100	231	231	562	62	82	140	353	448	941	521
August	105	282	187	574	124	51	124	345	453	922	666
September	97	279	182	558	86	108	124	351	399	874	584
October	112	294	240	646	92	49	125	341	447	913	650
November	106	327	250	683	108	91	117	373	436	926	687
December	103	288	245	636	76	70	110	402	478	990	578
Total	1,133	3,203	2,432	6,768	1,067	965	110	402	478	990	6,941
By refining district:											
East Coast	89	406	24	519	883	219	2	48	10	60	2,836
Appalachian No. 1	282	134	498	914			35	55	54	144	
Appalachian No. 2	--	--	--	--	36	39	--	--	--	--	1,167
Indiana, Illinois, Kentucky, etc	1	315	249	565			--	22	125	147	
Minnesota, Wisconsin, etc	--	--	--	--			--	--	--	--	
Oklahoma, Kansas, etc	293	257	79	629			31	42	8	81	
Texas Inland	79	--	--	79	132	636	14	--	--	14	1,879
Texas Gulf Coast	145	605	1,127	1,877			15	39	213	267	
Louisiana Gulf Coast	42	744	146	932			10	138	21	169	
Arkansas, Louisana Inland, etc	194	--	--	194			1	--	--	1	
New Mexico	--	--	--	--	--	--	--	--	--	--	
Rocky Mountain	8	56	34	98			2	29	24	55	73
West Coast	--	686	275	961	16	71	--	29	23	52	986
Total	1,133	3,203	2,432	6,768	1,067	965	110	402	478	990	6,941

p Preliminary.
[1] Conversion factor: 280 pounds to the barrel.

Table 53.—Salient statistics of petroleum coke in the United States, by month and refining district[1]

(Thousand barrels unless otherwise stated)

	1972							1973 p						
	Production			Yield (percent)	Exports	Stocks (end of period)	Domestic demand	Production			Yield (percent)	Exports	Stocks (end of period)	Domestic demand
	Marketable	Catalyst	Total					Marketable	Catalyst	Total				
By month:														
January	5,356	4,136	9,492	2.8	1,104	8,049	7,784	5,752	5,660	11,412	2.9	2,259	8,599	8,370
February	5,417	3,997	9,414	2.8	1,454	8,798	7,211	5,173	4,888	10,061	2.9	2,797	8,976	6,887
March	5,527	4,035	9,562	2.7	3,432	8,006	6,922	5,750	5,385	11,135	3.0	2,850	9,739	7,522
April	5,181	3,669	8,850	2.6	2,655	7,747	6,454	5,612	5,263	10,875	3.0	3,931	9,475	7,208
May	5,423	3,642	9,065	2.6	2,683	7,686	6,443	5,383	5,763	11,146	2.9	3,002	9,609	8,010
June	5,361	3,743	9,104	2.6	2,733	7,944	6,113	6,155	5,419	11,574	2.9	2,958	9,824	8,401
July	5,386	4,035	9,421	2.5	2,271	8,304	6,790	6,019	5,736	11,755	2.9	3,007	10,287	8,285
August	5,858	5,338	11,196	3.0	3,022	8,067	8,411	5,807	5,739	11,546	2.9	2,758	10,435	8,640
September	5,639	4,919	10,558	2.9	3,335	7,742	7,548	4,941	5,394	10,335	2.7	3,144	10,136	7,490
October	5,932	5,162	11,094	3.0	2,900	7,848	8,088	5,795	5,282	11,077	2.8	2,555	9,783	8,875
November	5,925	4,814	10,739	3.0	2,870	7,423	8,294	5,406	5,091	10,497	2.8	2,590	10,087	7,603
December	5,809	5,461	11,270	2.9	2,659	7,816	8,218	5,734	5,143	10,877	2.8	3,155	9,974	7,835
Total	66,814	52,951	119,765	2.8	31,118	7,816	88,276	67,527	64,763	132,290	2.9	35,006	9,974	95,126
By refining district:														
East Coast	4,995	8,192	13,187	2.8	395	1,042	13,113	5,506	7,699	13,205	2.5	582	2,726	11,361
Appalachian No. 1	--	236	236	.4		--		--	422	422	.6		--	
Appalachian No. 2	--	129	129	.7		--		--	289	289	1.4		--	
Indiana, Illinois, Kentucky, etc	9,692	1,269	3,405	4.1	2,319	691	31,220	10,758	12,973	23,731	2.9	2,176	1,066	35,852
Minnesota, Wisconsin, etc	2,136	1,269	3,405	4.1		620		1,964	1,654	3,618	4.0		685	
Oklahoma, Kansas, etc	7,158	3,246	10,404	3.1		177		6,217	5,018	11,235	3.4		582	
Texas Inland	523	2,288	2,811	1.8		12		460	2,853	3,313	2.2		5	
Texas Gulf Coast	8,186	13,501	21,687	2.3		306		8,355	15,363	23,718	2.4		396	
Louisiana Gulf Coast	8,948	5,394	14,342	2.4	9,612	112	30,408	8,828	5,750	14,578	2.3	10,979	111	31,764
Arkansas, Louisiana Inland, etc	610	348	958	2.0		438		438	202	640	1.3		49	
New Mexico	--	176	176	1.1		--		--	187	187	1.1		--	
Rocky Mountain	1,350	2,209	3,559	2.5	--	1,803	3,561	1,316	2,667	3,983	2.6	8	1,825	3,953
West Coast	23,216	5,426	28,642	4.1	18,792	2,615	9,974	23,685	9,686	33,371	4.5	21,261	2,529	12.196
Total	66,814	52,951	119,765	2.8	31,118	7,816	88,276	67,527	64,763	132,290	2.9	35,006	9,974	95,126

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[1] Conversion factor: 5.0 barrels to the short ton.

Table 54.—Production of miscellaneous finished oils at refineries and natural gas processing plants in the United States in 1973, by district and class

(Thousand barrels)

District	Absorption	Petrolatum	Specialty oils [1]	Petrochemicals	Other products	Total
East Coast	--	--	1,197	891	18	2,106
Appalachian No. 1	9	104	39	17	3	172
Appalachian No. 2	--	--	35	--	18	53
Indiana, Illinois, Kentucky, etc	91	13	680	573	216	1,573
Minnesota, Wisconsin, North Dakota, South Dakota	--	--	--	10	--	10
Oklahoma, Kansas, etc	126	151	833	--	304	1,414
Texas Inland	172	--	922	952	156	2,202
Texas Gulf	54	342	1,586	3,362	217	5,561
Louisiana Gulf	642	126	417	2,090	554	3,829
Arkansas, Louisiana Inland	71	--	159	87	--	317
Rocky Mountain, New Mexico	2	30	--	39	34	105
West Coast	12	43	1,188	884	392	2,519
Total:						
1973	1,179	809	7,056	8,905	1,912	19,861
1972	1,151	764	6,337	6,719	1,421	16,392

[1] Specialty oils include: Hydraulic, 207; insulating, 393; medicinal, 286, rust preventatives, 17; sand-frac, 922; spray oils, 290; and other, 4,941.

Table 55.—Petroleum oils, crude and refined, exported from the United States, including shipments, to territories and possessions, by month[1]

(Thousand barrels)

Year and class	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1972													
Crude petroleum	--	--	--	187	--	--	--	--	--	--	--	--	187
Refined products:													
Gasoline:[2]													
Motor	45	14	20	28	13	10	27	17	30	178	23	19	424
Aviation	48	9	31	27	7	8	19	19	22	13	15	14	232
Total gasoline	93	23	51	55	20	18	46	36	52	191	38	33	656
Jet fuel:													
Naphtha type	99	18	104	15	145	152	127	15	16	16	17	187	911
Kerosine type	--	10	--	--	--	--	--	--	--	--	--	36	46
Total jet fuel	99	28	104	15	145	152	127	15	16	16	17	223	957
Liquefied gases:													
Butane	393	390	534	376	394	378	413	414	415	399	432	429	4,967
Propane	498	488	572	403	442	429	435	598	526	684	633	794	6,502
Total liquefied gases	891	878	1,106	779	836	807	848	1,012	941	1,083	1,065	1,223	11,469
Kerosine	8	3	8	4	4	11	19	8	4	6	9	7	91
Distillate fuel oil	96	138	92	237	53	105	64	20	116	12	46	232	1,211
Residual fuel oil	547	548	1,806	1,507	567	603	1,099	1,259	856	1,428	873	967	12,060
Petrochemical feedstocks	580	384	374	309	297	430	418	388	99	134	824	390	4,627
Special naphthas	119	72	172	98	156	99	227	118	117	115	94	122	1,509
Lubricants	1,457	975	1,509	1,353	1,156	1,114	1,129	1,244	1,117	1,173	1,383	1,373	14,983
Wax	122	98	165	88	130	67	90	90	63	55	94	68	1,130
Coke	1,104	1,454	3,432	2,655	2,683	2,733	2,271	3,022	3,335	2,900	2,870	2,659	31,118
Asphalt	27	27	31	19	24	27	24	44	37	24	24	25	333
Miscellaneous	114	78	77	62	102	91	79	90	87	94	85	99	1,058
Total refined	5,257	4,706	8,927	7,181	6,173	6,257	6,441	7,346	6,840	7,231	7,422	7,421	81,202
Total crude and refined	5,257	4,706	8,927	7,368	6,173	6,257	6,441	7,346	6,840	7,231	7,422	7,421	81,389

1973 p													
Crude petroleum	--	--	--	--	128	--	232	--	160	--	--	177	697
Refined products:													
Gasoline: [2]													
Motor	32	142	22	130	151	28	70	8	27	252	460	146	1,468
Aviation	7	12	67	4	6	6	12	49	8	10	8	9	198
Total gasoline	39	154	89	134	157	34	82	57	35	262	468	155	1,666
Jet fuel:													
Naphtha type	180	184	169	54	22	11	3	--	--	1	11	5	640
Kerosine type	34	21	29	172	112	128	105	32	58	100	92	45	928
Total jet fuel	214	205	198	226	134	139	108	32	58	101	103	50	1,568
Liquefied gases:													
Butane	385	411	490	336	318	330	396	386	366	359	344	334	4,455
Propane	508	728	619	461	459	375	392	434	400	399	339	387	5,501
Total liquefied gases	893	1,139	1,109	797	777	705	788	820	766	758	683	721	9,956
Kerosine	9	8	7	--	8	--	4	8	7	7	24	3	85
Distillate fuel oil	333	67	72	198	54	254	106	265	763	722	97	309	3,240
Residual fuel oil	1,031	948	801	1,233	1,152	243	1,107	912	653	645	205	301	9,231
Petrochemical feedstocks	149	634	184	251	390	588	576	588	365	752	630	694	5,801
Special naphthas	169	108	134	111	137	140	160	125	119	111	149	189	1,652
Lubricants	1,215	1,075	1,250	1,175	1,196	1,196	1,050	982	967	773	875	1,068	12,822
Wax	121	60	88	85	87	73	82	51	108	49	91	70	965
Coke	2,259	2,797	2,850	3,931	3,002	2,958	3,007	2,758	3,144	2,555	2,590	3,155	35,006
Asphalt	18	16	23	34	29	27	26	34	31	43	29	30	340
Miscellaneous	64	77	128	76	91	88	119	114	98	89	116	123	1,183
Total refined	6,514	7,288	6,933	8,251	7,214	6,445	7,215	6,746	7,114	6,867	6,060	6,868	83,515
Total crude and refined	6,514	7,288	6,933	8,251	7,342	6,445	7,447	6,746	7,274	6,867	6,060	7,045	84,212

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[1] Compiled from records of U. S. Department of Commerce.
[2] Includes benzol, natural gasoline, and antiknock compounds.

Table 56.—Crude oil and petroleum products exported from the United States, by country of destination

(Thousand barrels)

	Crude oil	Gasoline	Special naphthas	Jet fuel	Kerosine	Distillate oil	Residual oil	Lubricating oil	Asphalt	Liquefied petroleum gases	Wax	Coke	Petrochemical feedstocks	Miscellaneous products	Total
1972															
North America:															
Canada	--	68	321	58	6	84	3,186	1,457	79	117	120	3,370	579	154	9,599
Mexico	--	262	62	199	--	45	1,818	247	176	10,330	148	1,720	36	18	15,061
Total	--	330	383	257	6	129	5,004	1,704	255	10,447	268	5,090	615	172	24,660
Central America and Caribbean:															
Bahamas	--	12	3	--	(1)	16	707	24	(1)	26	--	--	1	(1)	789
British West Indies	--	--	(1)	--	--	--	134	(1)	(1)	(1)	(1)	--	(1)	(1)	134
Jamaica	--	(1)	2	--	--	--	125	112	2	(1)	2	(1)	1	3	247
Netherlands Antilles	--	(1)	1	--	--	161	(1)	90	2	--	1	--	(1)	(1)	255
Panama	--	--	6	--	--	--	542	49	(1)	--	6	--	1	1	605
Puerto Rico	--	2	r 62	--	(1)	(1)	196	497	--	2	25	r 452	21	r 12	r 1,269
Trinidad	--	(1)	20	--	--	--	--	55	1	--	3	--	2	2	83
Virgin Islands	--	r 83	r 1	10	r 5	r 11	1	r 22	3	(1)	r 1	1	(1)	7	r 145
Others	--	1	39	--	--	--	--	r 223	8	8	50	2	15	15	r 361
Total	--	r 98	r 134	10	r 5	r 188	1,705	r 1,072	16	36	r 88	r 455	41	r 40	r 3,888
South America:															
Argentina	--	(1)	5	--	(1)	r 9	(1)	410	(1)	--	4	--	11	2	r 441
Brazil	--	r 30	86	--	(1)	--	188	1,903	2	47	8	378	325	177	r 3,144
Chile	--	--	1	--	--	1	8	211	--	--	10	--	1	17	249
Ecuador	--	--	1	--	--	--	--	26	2	1	10	--	1	3	44
Peru	--	(1)	(1)	--	(1)	--	(1)	88	(1)	--	5	--	1	r 4	r 98
Venezuela	--	2	50	--	2	--	3	96	6	--	12	68	1	20	260
Others	--	(1)	6	--	1	--	1	105	1	4	r 7	--	4	9	r 138
Total	--	r 32	149	--	3	r 10	200	2,839	11	52	r 56	446	344	r 232	r 4,374
Europe:															
Belgium	--	11	42	--	--	--	135	959	3	(1)	23	3,375	22	11	4,581
Denmark	--	(1)	1	--	--	--	238	22	1	(1)	5	--	1	2	270
France	--	3	78	--	--	1	27	108	1	28	40	726	688	3	1,703
Greece	--	(1)	1	--	(1)	--	202	25	--	(1)	--	246	1	1	476
Ireland	--	--	1	--	--	--	122	12	(1)	--	1	--	(1)	(1)	136
Italy	--	1	52	--	4	27	993	377	2	(1)	82	1,290	273	40	3,141
Netherlands	--	r 1	161	--	2	63	436	680	--	--	22	2,301	612	75	r 4,353
Norway	--	--	1	--	--	--	--	16	--	--	1	815	1	2	836
Spain	--	(1)	1	--	--	--	302	104	2	--	14	684	461	4	1,572
Sweden	--	1	1	--	--	--	276	99	1	--	r 4	r 533	4	4	923
United Kingdom	--	5	59	--	--	1	1,511	1,051	3	1	45	365	r 648	16	r 3,705
West Germany	--	1	52	--	30	1	(1)	441	2	(1)	299	4,884	32	40	5,782
Yugoslavia	--	--	(1)	--	--	--	--	2	--	--	--	121	1	1	125
Others	--	2	6	--	--	1	1	96	3	3	10	3	5	5	135
Total	--	r 25	456	--	36	94	4,243	3,992	18	32	r 546	r 15,343	r 2,749	204	r 27,738

Middle East:															
Bahrain	--	(1)	(1)	--	--	--	--	6	(1)	(1)	--	165	1	1	173
Iran	--	(1)	1	--	(1)	--	(1)	37	1	(1)	--	56	1	2	98
Israel	--	(1)	(1)	--	6	--	(1)	16	1	(1)	(1)	(1)	3	2	58
Saudi Arabia	--	(1)	2	--	--	--	--	190	--	(1)	--	--	3	1	196
Turkey	--	(1)	(1)	--	--	--	--	558	--	--	(1)	--	3	14	575
Others	--	(1)	1	--	--	--	(1)	52	2	--	(1)	(1)	2	1	58
Total	--	(1)	4	--	6	--	(1)	889	4	(1)	(1)	221	13	21	1,158
Africa:															
Egypt, Arab Republic of	--	(1)	(1)	--	--	--	--	151	--	--	(1)	--	(1)	(1)	151
Ghana	--	--	1	--	(1)	--	--	92	(1)	--	--	264	1	2	360
Nigeria	--	1	(1)	--	2	--	--	36	1	--	(1)	--	1	11	52
South Africa, Republic of	--	1	58	--	2	--	330	241	8	2	35	38	121	28	864
Tunisia	--	--	--	--	(1)	--	--	117	(1)	--	(1)	--	--	--	117
Others	--	(1)	11	--	1	--	21	116	8	3	12	(1)	15	13	200
Total	--	2	70	--	5	--	351	753	17	5	47	302	138	54	1,744
Asia and Oceania:															
Australia	--	1	61	--	2	--	2	217	2	2	22	507	608	50	1,474
French Pacific Islands	--	82	--	--	10	12	29	10	1	(1)	--	--	(1)	--	144
India	--	(1)	12	--	--	--	(1)	465	--	(1)	6	81	2	1	567
Indonesia	--	1	1	--	--	--	--	147	(1)	--	1	--	4	18	172
Japan	187	2	125	--	14	203	374	1,246	4	888	55	8,305	90	169	11,662
Malaysia	--	(1)	1	--	--	--	--	130	(1)	--	1	62	(1)	1	195
New Zealand	--	(1)	9	--	--	--	(1)	28	(1)	3	7	193	5	46	291
Philippines	--	2	17	--	1	--	62	285	(1)	(1)	9	(1)	4	14	394
South Vietnam	--	--	(1)	--	--	--	--	303	(1)	--	11	--	1	6	321
Taiwan	--	(1)	1	--	--	--	--	56	2	--	4	68	8	10	149
Thailand	--	(1)	7	--	--	--	(1)	401	--	--	--	--	--	6	414
U.S. Pacific Islands [2]	--	81	47	690	3	575	5	64	--	--	--	--	--	--	1,465
Others	--	(1)	32	--	--	--	85	382	3	4	9	45	5	14	579
Total	187	169	313	690	30	790	557	3,734	12	897	125	9,261	r 727	335	r 17,827
Total exports	187	r 656	r 1,509	957	r 91	r 1,211	12,060	r 14,983	333	11,469	1,130	r 31,118	r 4,627	r 1,058	r 81,389

See footnotes at end of table.

Table 56.—Crude oil and petroleum products exported from the United States, by country of destination—Continued

(Thousand barrels)

	Crude oil	Gasoline	Special naphthas	Jet fuel	Kerosine	Distillate oil	Residual oil	Lubricating oil	Asphalt	Liquefied petroleum gases	Wax	Coke	Petrochemical feedstocks	Miscellaneous products	Total
1973 p															
North America:															
Canada	--	32	255	642	4	22	3,390	1,549	67	363	116	4,141	664	182	11,427
Mexico	--	932	89	171	(1)	801	2,356	184	207	9,128	75	1,990	30	21	15,984
Total	--	964	344	813	4	823	5,746	1,733	274	9,491	191	6,131	694	203	27,411
Central America and Caribbean:															
Bahamas	--	6	3	1	--	6	67	38	--	2	(1)	--	1	1	125
British West Indies	--	--	(1)	--	--	--	--	2	1	--	(1)	--	1	(1)	4
Jamaica	--	--	2	--	--	(1)	--	183	3	(1)	1	--	1	3	193
Netherlands Antilles	--	(1)	2	(1)	--	196	837	32	1	--	(1)	32	(1)	1	1,101
Panama	--	--	13	--	--	50	486	58	1	--	4	31	3	2	648
Puerto Rico	--	52	87	--	(1)	(1)	122	385	4	34	23	336	20	17	1,080
Trinidad	--	--	10	--	--	--	1	34	2	--	(1)	--	1	1	49
Virgin Islands	--	78	1	--	2	3	1	29	1	2	(1)	1	1	(1)	119
Others	--	2	55	--	5	1	--	255	10	12	33	--	9	16	398
Total	--	138	173	1	7	256	1,514	1,016	23	50	61	400	37	41	3,717
South America:															
Argentina	--	165	9	--	(1)	--	--	39	(1)	(1)	2	--	17	2	234
Brazil	--	122	123	--	(1)	--	59	1,943	2	--	8	316	226	158	2,957
Chile	--	(1)	2	--	--	(1)	2	262	--	--	4	--	(1)	8	278
Ecuador	--	--	3	--	(1)	--	--	25	1	(1)	(1)	--	3	6	38
Peru	--	--	2	--	1	--	163	91	(1)	(1)	4	--	2	5	268
Venezuela	--	(1)	33	--	2	184	1	47	4	(1)	7	79	1	30	388
Others	--	(1)	4	--	(1)	--	2	102	1	1	3	--	5	13	131
Total	--	287	176	--	3	184	227	2,509	8	1	28	395	254	222	4,294
Europe:															
Belgium	177	1	4	--	--	(1)	--	896	2	1	4	4,480	17	8	5,590
Denmark	--	--	1	--	--	154	162	60	(1)	(1)	4	1	1	2	385
France	--	3	44	--	(1)	--	(1)	77	1	(1)	34	1,060	674	16	1,909
Greece	--	--	1	(1)	--	--	--	19	(1)	--	(1)	256	1	2	279
Ireland	--	--	(1)	--	--	--	--	9	(1)	--	1	--	(1)	(1)	10
Italy	--	2	40	--	4	4	461	388	1	(1)	38	1,413	846	52	3,249
Netherlands	--	10	305	--	2	353	1	231	1	(1)	12	2,797	857	94	4,663
Norway	--	(1)	(1)	--	--	--	--	15	1	--	(1)	994	1	2	1,013
Spain	--	(1)	20	--	--	1	86	59	(1)	1	6	567	539	13	1,292
Sweden	--	(1)	(1)	--	(1)	--	--	102	(1)	--	4	591	113	4	814
United Kingdom	--	5	176	--	--	625	393	756	1	2	19	441	700	23	3,141
West Germany	--	4	36	--	28	2	--	301	2	1	414	4,623	9	30	5,450
Yugoslavia	--	(1)	(1)	--	--	--	(1)	5	--	--	--	187	1	(1)	193
Others	--	2	2	--	--	--	--	62	2	--	3	7	6	5	89
Total	177	27	629	(1)	34	1,139	1,103	2,980	11	5	539	17,417	3,765	251	28,077

Middle East:															
Bahrain	--	(1)	(1)	--	--	--	--	3	(1)	1	(1)	254	(1)	1	259
Iran	--	2	2	--	1	--	(1)	46	(1)	--	1	112	2	6	172
Israel	--	--	1	--	--	--	1	57	(1)	3	2	--	4	3	71
Saudi Arabia	--	(1)	1	--	--	1	--	123	1	1	(1)	--	2	1	130
Turkey	--	(1)	1	--	--	--	21	134	--	--	(1)	--	81	15	252
Others	--	1	2	--	--	--	2	61	3	--	(1)	--	3	1	73
Total	--	3	7	--	1	1	24	424	4	5	3	366	92	27	957
Africa:															
Egypt, Arab Republic of	--	(1)	(1)	--	--	--	--	105	--	--	--	--	1	(1)	106
Ghana	--	(1)	2	--	--	--	--	51	1	--	(1)	291	4	3	352
Nigeria	--	1	1	--	1	--	1	40	--	--	1	(1)	1	10	56
South Africa, Republic of	--	2	49	--	2	1	123	215	6	1	29	42	263	38	771
Tunisia	--	--	(1)	--	(1)	--	--	99	(1)	--	--	--	--	--	99
Others	--	1	3	--	1	--	--	136	5	--	4	--	8	19	177
Total	--	4	55	--	4	1	124	646	12	1	34	333	277	70	1,561
Asia and Oceania:															
Australia	--	2	59	--	8	--	1	188	1	(1)	10	379	607	50	1,305
French Pacific Islands	--	110	--	10	13	49	20	9	(1)	--	--	--	(1)	--	211
India	--	(1)	5	--	--	--	--	463	1	(1)	4	--	1	(1)	474
Indonesia	--	(1)	1	--	1	--	--	65	1	(1)	(1)	--	13	4	85
Japan	520	1	115	--	8	86	393	1,306	3	401	57	9,197	41	179	12,307
Malaysia	--	(1)	27	--	--	--	(1)	160	(1)	--	--	110	1	2	300
New Zealand	--	(1)	5	--	--	--	--	20	(1)	1	3	239	2	37	307
Philippines	--	(1)	19	--	(1)	--	--	367	(1)	--	7	1	7	20	421
South Vietnam	--	--	(1)	--	--	--	(1)	381	(1)	--	6	--	(1)	3	390
Taiwan	--	--	1	--	--	1	(1)	69	(1)	--	5	27	5	34	142
Thailand	--	(1)	7	--	--	--	--	257	(1)	(1)	2	--	1	10	277
U.S. Pacific Islands [2]	--	128	--	744	2	700	1	12	--	--	--	--	--	--	1,587
Others	--	2	29	--	--	--	78	217	2	1	15	11	4	30	389
Total	520	243	268	754	32	836	493	3,514	8	403	109	9,964	682	369	18,195
Total exports	697	1,666	1,652	1,568	85	3,240	9,231	12,822	340	9,956	965	35,006	5,801	1,183	84,212

r Revised. p Preliminary.
1 Less than ½ unit.
2 Data reported by shippers to the Bureau of Mines.

Table 57.—Crude, refined products, plant condensate and unfinished oils imported into the United States, by month[1]

(Thousand barrels)

Year and class	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1972													
Crude petroleum	63,419	60,344	64,066	60,129	66,958	62,544	67,635	65,463	70,909	78,003	68,978	82,687	811,135
Petroleum products:													
Motor gasoline	1,574	1,903	2,076	1,569	2,287	2,244	2,136	2,512	2,084	2,195	2,080	2,127	24,787
Jet fuel:													
Naphtha type	836	610	391	444	1,123	1,121	825	730	894	1,657	1,835	1,532	11,998
Kerosine type	4,705	5,778	4,776	3,270	3,812	7,636	4,286	4,882	4,796	7,220	3,699	4,316	59,176
Total jet fuel	5,541	6,388	5,167	3,714	4,935	8,757	5,111	5,612	5,690	8,877	5,534	5,848	71,174
Liquefied gases													
Butane	1,814	1,485	1,997	958	1,095	1,000	1,067	1,029	1,146	1,603	1,564	1,792	16,550
Propane	2,517	2,035	1,559	820	761	610	531	751	873	1,691	1,719	1,984	15,851
Total liquefied gases	4,331	3,520	3,556	1,778	1,856	1,610	1,598	1,780	2,019	3,294	3,283	3,776	32,401
Kerosine	1	24	--	1	1	--	41	28	83	45	116	186	526
Distillate fuel oil	6,106	5,930	7,971	5,662	4,086	2,883	3,018	2,862	2,963	6,299	6,820	11,849	66,449
Residual fuel oil	58,658	55,761	59,718	50,265	48,770	49,455	49,416	51,244	48,736	51,303	53,075	61,000	637,401
Petrochemical feedstocks	130	181	389	21	581	210	274	301	332	340	87	332	3,178
Special naphthas	304	24	7	52	4	4	24	160	5	256	4	19	863
Lubricants	1	1	--	2	1	1	112	63	78	122	170	118	669
Wax	13	2	3	4	2	3	58	29	46	38	78	59	335
Asphalt	438	483	312	548	721	868	762	1,157	1,233	867	1,131	743	9,263
Plant condensate	1,748	1,758	2,196	1,782	2,701	2,414	2,770	3,309	3,039	2,963	3,365	3,383	31,428
Unfinished oils	5,520	4,189	3,234	3,542	2,495	3,011	3,339	3,600	3,956	4,214	3,846	4,759	45,705
Total petroleum products	84,365	80,164	84,629	68,940	68,440	71,460	68,659	72,657	70,264	80,813	79,589	94,199	924,179
Total crude and products	147,784	140,508	148,695	129,069	135,398	134,004	136,294	138,120	141,173	158,816	148,567	176,886	1,735,314

1973 p													
Crude petroleum	84,693	80,433	98,021	91,459	99,654	96,613	108,530	111,368	104,117	115,905	103,570	89,633	1,183,996
Petroleum products:													
Motor gasoline	1,841	2,667	2,193	1,902	3,146	5,214	4.110	4,871	3,816	6,020	6,492	5,834	48,106
Jet fuel:													
Naphtha type	777	440	394	846	681	926	981	1,858	1,219	2,218	1,695	1,280	13,315
Kerosine type	6,380	5,759	4,330	3,507	5,846	3,961	6,166	3,715	5,658	4,232	6,190	5,226	60,970
Total jet fuel	7,157	6,199	4,724	4,353	6,527	4,887	7,147	5,573	6,877	6,450	7,885	6,506	74,285
Liquefied gases:													
Butane	2,281	1,926	1,799	1,216	1,915	1,117	1,603	2,289	1,693	2,103	2,307	1,938	22,187
Propane	4,034	3,391	2,759	1,473	1,596	1,156	1,080	1,554	1,268	2,507	2,791	2,005	25,614
Total liquefied gases	6,315	5,317	4,558	2,689	3,511	2,273	2,683	3,843	2,961	4,610	5,098	3,943	47,801
Kerosine	6	4	12	--	6	8	--	224	156	--	245	124	785
Distillate fuel oil	11,154	18,817	17,953	7,211	7,666	6,461	9,880	8,876	8,945	13,531	14,794	13,464	138,752
Residual fuel oil	61,290	58,025	67,742	51,089	51,657	52,716	49,515	57,346	55,248	48,235	58,248	55,595	666,706
Petrochemical feedstocks	318	580	191	324	216	358	214	429	171	331	279	414	3,825
Special naphthas	7	4	33	5	6	6	9	5	5	--	5	3	88
Lubricants	210	160	230	205	35	119	121	217	170	113	333	119	2,032
Wax	100	61	103	94	71	90	62	124	86	92	108	76	1,067
Asphalt	398	304	428	269	682	372	1,306	1,118	1,139	733	726	969	8,444
Plant condensate	3,367	3,411	3,454	3,265	3,153	2,622	3,281	3,166	2,935	2,665	3,188	2,968	37,475
Unfinished oils	3,278	2,479	4,181	4,786	4,002	4,642	4.475	4,515	4,601	3,588	4,953	4,661	50,161
Total petroleum products	95,441	98,028	105,802	76,192	80,678	79,768	82,803	90,307	87,110	86,368	102,354	94,676	1,079,527
Total crude and products	180,134	178,461	203,823	167,651	180,332	176,381	191,333	201,675	191,227	202,273	205,924	184,309	2,263,523

p Preliminary.

[1] Imports for onshore use of military jet fuel, distillate and residual fuel oils, and receipts from Puerto Rico, the Virgin Islands, and Guam included in these data are based on figures reported to the Department of the Interior. All other import figures are compiled from Department of Commerce data.

Table 58.—Crude oil and petroleum products imported into the United States, by country and receiving district

(Thousand barrels)

Country and PAD district	Crude oil [1]	Gasoline	Special naphtha	Kerosine	Distillate fuel oil [2]	Residual fuel oil [2]	Jet fuel		Liquefied gases	Plant condensate	Asphalt	Unfinished oils [1]	Lubricants	Wax	Petrochemical feed stocks	Total
							Naphtha type	Kerosine type								
1972																
North America:																
Canada	312,440	513	286	123	2,258	28,702	--	1,605	27,853	31,282	408	93	5	16	--	405,584
Mexico	--	--	--	--	--	1,775	--	--	--	--	--	5,925	--	10	--	7,710
Total	312,440	513	286	123	2,258	30,477	--	1,605	27,853	31,282	408	6,018	5	26	--	413,294
Central America and Caribbean:																
Bahamas	--	--	--	148	1,431	54,746	10	6,503	--	--	--	679	--	--	--	63,517
El Salvador	--	--	--	--	--	145	--	--	--	--	--	--	--	--	--	145
Honduras	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	1
Leeward and Windward Islands	--	--	--	--	158	714	--	19	--	--	--	434	--	--	--	1,325
Netherlands Antilles	--	628	78	--	12,535	115,550	1,474	18,378	--	--	3,638	2,984	--	--	158	155,423
Panama	--	63	--	--	53	314	--	1,497	--	--	--	451	--	--	179	2,557
Puerto Rico	--	20,023	--	255	9,546	--	--	833	--	--	--	5,425	653	264	229	37,228
Trinidad	8,626	--	--	--	2,797	58,010	2,948	8,793	--	--	9	235	--	--	1,122	82,540
Virgin Islands	--	3,006	--	--	8,767	91,424	3,790	--	--	--	--	13,823	--	--	130	120,940
Total	8,626	23,720	78	403	35,287	320,904	8,222	36,023	--	--	3,647	24,031	653	264	1,818	463,676
South America:																
Argentina	407	--	--	--	--	15	--	--	--	--	--	--	--	--	--	422
Brazil	--	--	--	--	786	994	--	--	--	--	--	--	--	--	--	1,780
Chile	--	--	--	--	--	--	--	--	126	--	--	--	--	--	--	126
Colombia	1,695	--	--	--	778	3,189	--	--	--	--	--	16	--	11	--	5,689
Ecuador	5,331	--	--	--	--	548	--	--	--	--	--	--	--	--	--	5,879
Peru	--	--	--	--	--	625	--	--	--	--	--	--	--	--	--	625
Venezuela	93,300	33	499	--	17,898	210,480	1,412	9,321	3,993	146	5,163	8,615	--	13	293	351,166
Total	100,733	33	499	--	19,462	215,851	1,412	9,321	4,119	146	5,163	8,631	--	24	293	365,687
Europe:																
Belgium	--	--	--	--	336	6,524	33	298	--	--	--	--	--	--	--	7,191
Denmark	--	--	--	--	--	122	--	--	--	--	--	--	--	--	--	122
France	--	--	--	--	--	2,156	--	128	--	--	--	--	1	--	166	2,451
Greece	--	--	--	--	--	145	--	--	--	--	--	--	--	--	--	145
Italy	--	196	--	--	3,453	24,979	--	1,411	--	--	--	--	--	--	341	30,380
Netherlands	--	--	--	--	974	5,996	13	235	--	--	45	535	3	--	--	7,801
Romania	--	--	--	--	2,973	948	--	--	--	--	--	--	--	--	--	3,921
Spain	--	136	--	--	84	6,171	--	49	--	--	--	--	--	--	--	6,440
Sweden	--	--	--	--	--	662	--	--	--	--	--	--	--	--	--	662
U.S.S.R	323	--	--	--	190	2,360	--	--	--	--	--	141	--	--	--	3,014
United Kingdom	--	--	--	--	--	3,200	--	--	1	--	--	--	4	--	165	3,370
West Germany	--	--	--	--	--	2	--	--	--	--	--	--	3	4	--	9
Total	323	332	--	--	8,010	53,265	46	2,121	1	--	45	676	11	4	672	65,506

Middle East:																
Bahrain	--	--	--	--	46	1,154	3	2,708	--	--	--	1,492	--	--	--	5,403
Iran	49,700	--	--	--	143	407	--	1,415	--	--	--	--	--	--	234	51,899
Iraq	1,315	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,315
Kuwait	13,205	--	--	--	931	72	--	93	5	--	--	2,083	--	--	--	16,389
Oman	--	--	--	--	--	--	--	--	25	--	--	--	--	--	--	25
Qatar	1,263	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,263
Saudi Arabia	63,626	--	--	--	77	3,720	196	190	210	--	--	1,381	--	--	--	69,400
United Arab Emirates	26,873	--	--	--	--	--	--	--	--	--	--	--	--	--	--	26,873
Yemen	--	--	--	--	--	--	--	407	--	--	--	--	--	--	--	407
Total	155,982	--	--	--	1,197	5,353	199	4,813	240	--	--	4,956	--	--	234	172,974
Africa:																
Algeria	31,753	--	--	--	--	2,081	--	--	--	--	--	--	--	--	--	33,834
Angola	5,785	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5,785
Canary Islands	--	--	--	--	--	--	--	--	--	--	--	--	--	--	161	161
Egypt, Arab Republic	3,091	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3,091
Gabon	--	--	--	--	--	109	--	--	--	--	--	--	--	--	--	109
Ghana	--	--	--	--	--	240	--	--	--	--	--	--	--	--	--	240
Ivory Coast	--	--	--	--	--	360	--	--	--	--	--	--	--	--	--	360
Libya	40,069	--	--	--	--	4,668	--	--	120	--	--	--	--	--	--	44,857
Nigeria	88,887	--	--	--	62	2,882	--	--	--	--	--	--	--	--	--	91,831
Tunisia	2,520	--	--	--	123	65	--	--	--	--	--	--	--	--	--	2,708
Total	172,105	--	--	--	185	10,405	--	--	120	--	--	--	--	--	161	182,976
Asia:																
Burma	--	--	--	--	--	--	--	--	--	--	--	--	--	2	--	2
Ceylon	--	--	--	--	--	6	--	--	--	--	--	--	--	--	--	6
Guam	--	--	--	--	--	45	259	--	--	--	--	--	--	--	--	304
Indonesia	59,633	--	--	--	--	554	--	--	--	--	--	--	--	--	--	60,187
Japan	--	--	--	--	--	24	--	2,033	--	--	--	59	--	15	--	2,131
Malaysia	966	--	--	--	--	204	422	1,470	68	--	--	300	--	--	--	3,430
Okinawa	--	--	--	--	--	--	132	--	--	--	--	475	--	--	--	607
Singapore	--	--	--	--	--	2	49	778	--	--	--	--	--	--	--	829
Taiwan	--	--	--	--	--	--	163	--	--	--	--	--	--	--	--	163
Turkey	--	189	--	--	--	--	--	--	--	--	--	354	--	--	--	543
Total	60,599	189	--	--	--	835	1,025	4,281	68	--	--	1,188	--	17	--	68,202
Oceania:																
Australia	327	--	--	--	--	262	--	1,012	--	--	--	--	--	--	--	1,601
Hawaii Trade Zone	--	--	--	--	50	49	1,094	--	--	--	--	205	--	--	--	1,398
Total	327	--	--	--	50	311	1,094	1,012	--	--	--	205	--	--	--	2,999
Total Imports	811,135	24,787	863	526	66,449	637,401	11,998	59,176	32,401	31,428	9,263	45,705	669	335	3,178	1,735,314
Imports by PAD district:																
District I	354,549	24,609	508	524	64,302	616,990	8,336	30,294	5,336	798	8,828	30,715	661	305	--	1,146,755
District II	171,338	43	49	2	473	5,458	--	2,789	14,441	16,478	55	--	5	5	--	211,136
District III	28,331	--	250	--	1,191	6,212	--	4,451	787	--	380	1,548	--	25	3,178	46,353
District IV	14,126	--	56	--	--	--	--	--	5,405	11,162	--	--	--	--	--	30,749
District V	242,791	135	--	--	483	8,741	3,662	21,642	6,432	2,990	--	13,442	3	--	--	300,321

See footnotes at end of table.

Table 58.—Crude oil and petroleum products imported into the United States, by country and receiving district—Continued

(Thousand barrels)

Country and PAD district	Crude oil [1]	Gasoline	Special naphtha	Kerosine	Distillate fuel oil [2]	Residual fuel oil [2]	Jet fuel: Naphtha type	Jet fuel: Kerosine type	Liquefied gases	Plant condensate	Asphalt	Unfinished oils [1]	Lubricants	Wax	Petrochemical feed stocks	Total
1973 p																
North America:																
Canada	365,370	4,432	88	25	2,091	33,278	--	2,937	31,653	37,460	506	1,183	3	35	163	479,224
Mexico	489	--	--	--	147	822	--	--	--	--	--	4,048	--	36	--	5,542
Total	365,859	4,432	88	25	2,238	34,100	--	2,937	31,653	37,460	506	5,231	3	71	163	484,766
Central America and Caribbean:																
Bahamas	--	--	--	--	7,360	46,547	30	7,119	--	--	--	1,103	--	--	169	62,328
El Salvador	--	--	--	--	--	--	--	--	--	--	42	--	--	--	--	42
Leeward and Windward Islands	--	290	--	--	139	484	--	--	--	--	--	--	--	--	--	913
Netherlands Antilles	--	5,716	--	--	22,664	153,703	1,111	17,854	235	--	5,099	2,982	--	--	--	209,364
Panama	--	327	--	124	791	79	35	1,138	--	--	--	--	--	--	--	2,494
Puerto Rico	--	18,816	--	--	8,526	--	--	214	--	--	--	5,376	1,972	691	639	36,234
Trinidad	21,739	1,175	--	--	4,791	49,183	3,003	7,996	--	--	19	2,573	--	--	976	91,455
Virgin Islands	--	5,169	--	11	23,741	78,791	2,824	--	--	--	--	9,296	--	--	341	120,173
Total	21,739	31,493	--	135	68,012	328,787	7,003	34,321	235	--	5,160	21,330	1,972	691	2,125	523,003
South America:																
Argentina	--	--	--	--	--	154	--	--	--	--	--	--	--	3	--	157
Bolivia	891	--	--	--	--	--	--	--	--	--	--	--	--	--	--	891
Brazil	--	--	--	--	1,433	1,856	--	--	--	--	--	--	--	9	--	3,298
Chile	--	--	--	--	--	--	--	--	138	--	--	--	--	--	--	138
Colombia	778	--	--	--	993	1,378	--	--	--	--	--	31	--	49	--	3,229
Ecuador	17,229	--	--	--	--	398	--	--	--	--	--	60	--	--	--	17,687
Peru	--	--	--	--	405	1,450	--	--	--	--	--	--	--	--	--	1,855
Venezuela	125,742	2,706	--	--	21,265	218,233	2,937	9,372	12,622	15	2,677	13,953	--	--	985	410,507
Total	144,640	2,706	--	--	24,096	223,469	2,937	9,372	12,760	15	2,677	14,044	--	61	985	437,762
Europe:																
Belgium	--	884	--	--	1,979	4,109	--	263	97	--	--	225	51	--	--	7,608
Denmark	--	--	--	--	554	--	--	--	--	--	--	--	--	--	--	554
France	--	--	--	--	149	1,218	--	--	225	--	--	--	2	1	--	1,595
Greece	--	160	--	--	590	830	--	--	--	--	--	774	--	--	--	2,354
Italy	--	1,811	--	152	9,453	31,913	--	1,051	--	--	--	400	--	--	--	44,780
Netherlands	--	2,000	--	--	12,875	3,384	--	6	237	--	101	39	1	--	304	18,947
Norway	--	--	--	--	--	250	--	--	103	--	--	--	--	--	--	353
Romania	--	619	--	--	1,734	639	--	--	--	--	--	--	--	--	--	2,992
Spain	--	417	--	--	4,485	3,561	--	271	--	--	--	--	--	--	--	8,734
Sweden	--	--	--	--	265	567	--	--	--	--	--	--	--	--	--	832
U.S.S.R	--	640	--	473	5,044	1,970	--	157	--	--	--	912	--	--	--	9,196
United Kingdom	--	260	--	--	2,038	2,145	--	--	856	--	--	186	--	8	--	5,493
West Germany	--	156	--	--	349	935	--	--	--	--	--	334	2	20	--	1,796
Total	--	6,947	--	625	39,515	51,521	--	1,748	1,518	--	101	2,870	56	29	304	105,234
Middle East:																
Bahrain	--	--	--	--	748	809	632	973	--	--	--	879	--	--	--	4,041
Iran	78,990	283	--	--	53	10	60	1,511	118	--	--	281	--	--	--	81,306
Iraq	1,529	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1,529

Israel	309	--	--	--	--	--	--	--	--	--	--	--	--	--	--	309
Kuwait	15,208	273	--	--	1,171	--	--	--	2	--	--	324	--	--	--	16,978
Oman	--	--	--	--	52	--	--	--	32	--	--	--	--	--	--	84
Qatar	2,663	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2,663
Saudi Arabia	168,525	155	--	--	355	2,572	1,271	454	595	--	--	3,881	--	--	88	177,896
United Arab Emirates	25,764	--	--	--	--	--	--	--	9	--	--	--	--	--	--	25,773
Yemen	--	--	--	--	--	--	--	676	--	--	--	--	--	--	--	676
Total	292,988	711	--	--	2,379	3,391	1,963	3,614	756	--	--	5,365	--	--	88	311,255
Africa:																
Algeria	43,619	--	--	--	963	4,329	--	--	55	--	--	--	--	--	--	48,966
Angola	17,753	--	--	--	--	140	--	--	--		--	--	--	--	--	17,893
Canary Islands	--	162	--	--	--	--	--	--	--	--	--	--	--	--	--	162
Chad	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	1
Egypt, Arab Republic	5,296	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5,296
Ghana	--	--	--	--	--	648	--	--	--	--	--	--	--	--	--	648
Kenya	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	1
Liberia	--	--	--	--	--	--	--	--	54	--	--	--	--	--	--	54
Libya	48,585	--	--	--	--	10,814	--	--	594	--	--	--	--	--	--	59,993
Nigeria	163,687	--	--	--	--	3,793	--	--	--	--	--	--	--	--	--	167,480
Republic of South Africa	--	--	--	--	--	--	--	--	--	--	--	--	--	3	--	3
Sudan	--	98	--	--	--	--	--	--	--	--	--	--	--	--	--	98
Tunisia	6,541	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6,541
Total	285,481	260	--	--	963	19,725	--	--	704	--	--	--	--	3	--	307,136
Asia:																
Burma	--	--	--	--	--	--	--	--	--	--	--	--	--	3	--	3
China, People's Republic	--	--	--	--	--	--	--	--	--	--	--	--	--	13	--	13
Indonesia	73,055	--	--	--	--	4,332	--	--	5	--	--	--	--	42	160	77,594
Japan	--	279	--	--	123	2	69	2,341	--	--	--	220	1	136	--	3,171
Malaysia	234	--	--	--	362	995	364	2,699	131	--	--	--	--	--	--	4,785
Pakistan	--	--	--	--	--	--	--	--	--	--	--	133	--	--	--	133
Phillipines	--	--	--	--	--	--	--	17	--	--	--	--	--	--	--	17
Singapore	--	156	--	--	442	--	507	3,446	1	--	--	746	--	18	--	5,316
Thailand	--	--	--	--	--	--	67	111	--	--	--	--	--	--	--	178
Taiwan	--	--	--	--	--	--	188	186	--	--	--	--	--	--	--	374
Turkey	--	1,122	--	--	150	--	--	--	--	--	--	--	--	--	--	1,272
Total	73,289	1,557	--	--	1,077	5,329	1,195	8,800	137	--	--	1,099	1	212	160	92,856
Oceania:																
Australia	--	--	--	--	226	--	63	176	38	--	--	126	--	--	--	629
Hawaii Trade Zone	--	--	--	--	246	384	154	2	--	--	--	96	--	--	--	882
Total	--	--	--	--	472	384	217	178	38	--	--	222	--	--	--	1,511
Total imports	1,183,996	48,106	88	785	138,752	666,706	13,315	60,970	47,801	[3] 37,475	8,444	50,161	2,032	1,067	3,825	2,263,523
Imports by PAD district:																
District I	466,074	42,603	6	785	121,598	633,168	10,000	32,522	8,549	1,777	8,093	26,216	1,980	883	359	1,354,613
District II	260,368	854	80	--	1,302	6,107	--	2,450	18,417	22,534	76	739	1	36	--	312,964
District III	145,654	3,510	--	--	12,161	10,102	--	5,902	9,116	--	275	10,681	51	132	3,466	201,050
District IV	16,182	568	2	--	89	1	--	--	5,496	10,115	--	--	--	--	--	32,403
District V	295,768	571	--	--	3,602	17,328	3,315	20,096	6,223	3,049	--	12,525	--	16	--	362,493

[p] Preliminary.
[1] Imports of crude oil and unfinished oils reported to the Bureau of Mines, imports for onshore military jet fuel, distillate and residual fuel oil, and receipts from Puerto Rico, the Virgin Islands, and Guam are based on data reported to the U.S. Department of the Interior.
[2] Includes quantities imported duty-free for supply of vessels and aircraft engaged in foreign trade.
[3] Excludes imports for substitute natural gas (SNG) plant feedstock use.

Table 59.—Crude petroleum: World production, by country

(Thousand 42-gallon barrels)

Country	1971	1972	1973 p
North America:			
Canada	491,846	560,693	648,348
Cuba e	785	775	775
Mexico [1]	177,274	185,011	191,482
Trinidad and Tobago	47,148	51,719	60,666
United States [1]	3,453,914	3,455,368	3,360,903
South America:			
Argentina	154,514	158,464	153,539
Barbados	19	31	10
Bolivia	13,206	15,967	17,266
Brazil	63,513	61,088	62,122
Chile	12,883	12,527	11,429
Colombia	78,101	71,674	66,844
Ecuador	1,354	28,579	76,221
Peru	22,588	23,635	25,767
Venezuela	1,295,406	1,178,487	1,228,594
Europe:			
Albania	8,674	10,508	14,345
Austria	17,549	17,284	17,982
Bulgaria	2,336	1,825	1,460
Czechoslovakia	1,356	1,322	1,221
Denmark	--	622	1,460
France	13,651	10,811	9,152
Germany, East	1,502	2,300	2,500
Germany, West	53,597	51,271	47,944
Hungary	14,879	15,084	15,176
Italy	8,952	7,850	7,082
Netherlands	11,727	10,885	10,169
Norway	2,081	12,126	11,166
Poland	3,116	2,574	2,908
Romania	102,479	105,296	106,578
Spain	874	1,020	5,932
U.S.S.R	2,778,300	2,895,900	3,094,350
United Kingdom [1]	1,499	2,628	3,296
Yugoslavia	21,932	23,709	24,680
Africa:			
Algeria	279,627	384,858	400,515
Angola	33,922	51,405	58,910
Congo (Brazzaville)	130	2,522	12,713
Egypt, Arab Republic of	106,993	84,693	60,483
Gabon	41,911	45,671	54,823
Libya	1,007,687	819,619	793,839
Morocco	172	216	320
Nigeria	558,375	665,282	749,820
Tunisia	31,542	31,607	29,828
Asia:			
Bahrain	27,346	25,508	24,948
Brunei	47,482	67,008	78,673
Burma	6,652	7,466	7,514
China, People's Republic of e	186,150	216,080	365,000
India	52,091	56,965	55,388
Indonesia	325,673	395,581	487,969
Iran	1,661,901	1,838,825	2,139,229
Iraq	624,312	529,419	736,607
Israel e [2]	44,618	43,920	32,193
Japan	5,529	5,242	5,142
Kuwait [3]	1,167,329	1,201,346	1,198,033
Malaysia	25,071	33,867	33,054
Oman	107,430	103,131	106,926
Pakistan	3,000	3,294	2,871
Qatar	156,882	176,545	208,152
Saudi Arabia [3]	1,741,149	2,202,049	2,870,026
Syrian Arab Republic	36,462	45,209	38,170
Taiwan	803	910	1,055
Thailand e	95	47	45
Turkey	25,031	24,416	24,273
United Arab Emirates:			
Abu Dhabi	341,007	384,190	479,192
Dubai	45,648	55,942	80,207
Oceania:			
Australia	112,914	119,516	142,277
New Zealand [1]	804	1,119	1,290
Total	17,662,793	18,600,501	20,560,852

e Estimate. p Preliminary.
[1] Includes field condensate.
[2] Estimates of Israeli production from Sinai peninsula oilfields included with Israel rather than with Arab Republic of Egypt.
[3] Data for both Kuwait and Saudi Arabia include those countries' share of production from the Kuwait-Saudi Arabia Partitioned Zone.

Phosphate Rock

By W. F. Stowasser [1]

World demand for phosphate rock exceeded production for the third consecutive year. Deliveries exceeded production by at least 2%, further reducing world stocks. Estimated world production in 1973 of approximately 108 million short tons, an increase of about 9% over the 1972 production level, was the highest recorded to date.

The average unit value of domestic phosphate rock increased from $5.09 per ton, f.o.b. plant in 1972, to $5.66 per ton in 1973. The increase in price reflects higher selling prices obtained for phosphate rock from new contracts written in 1972 and 1973. With higher prices posted to become effective after the first of the year, the upward trend of phosphate rock prices is expected to continue into 1974.

The Cost of Living Council removed price controls on domestic fertilizers and phosphate rock used to produce fertilizer and animal feed supplements in October 1973. It was anticipated that domestic prices of phosphate rock and fertilizers would increase and approach the substantially higher world prices when the price controls were lifted. With higher domestic prices, producers agreed to divert exports of phosphate rock and fertilizers into the domestic market to the degree needed to furnish adequate domestic supplies for the record-high acreage that will be planted in 1974.

Construction underway and plans to build significant additional plant capacity for wet-process phosphoric acid will, if projected estimates are correct, raise the 1973 effective capacity of 6.2 million tons of P_2O_5 to about 10.0 million tons of effective capacity by 1980. The growth of this segment of the industry will provide added pressure to increase domestic supplies of phosphate rock. With restrictions on production of phosphate rock expected to continue from factions opposed to strip mining and with limitations on the availability of domestic high-grade reserves for new mines, a gradual reduction in phosphate rock exports appears necessary to furnish sufficient raw materials for future domestic production of phosphate intermediates and fertilizers.

The phosphate rock industry's production capability was affected by shortages of electric power, from unscheduled repair and maintenance, particularly in older plants attempting to produce at consistently high rates, and in several instances, from depletion of high-grade ores. Because of these factors, a sharp downward revision of the capacity of Florida's phosphate rock industry was necessary.

Legislation and Government Programs.—The phosphate rock and fertilizer industries were regulated by a series of economic controls that started with a price freeze in August of 1971, continued with Phase 2 from November 1971 to January 1973, Phase 3 from January 1973 to June 1973, and Phase 4 from June 1973 to October 25, 1973. During Phases 2 and 3, domestic phosphate rock prices were not to increase to permit higher average profit levels than were recorded for the years 1968, 1969, and 1970. Unfortunately, the industry during the reference years was characterized by a surplus in production capacity, and the return on equity relative to net sales was negative. Although demand for phosphate rock increased during the late 1960's, the industry was able to supply the demand without increasing production capacity. The crossover occurred in 1971 and thereafter, when the demand both in the United States and the rest of the world exceeded available supply. With prices regulated in the United States, increasing amounts of phosphate rock and phosphatic fertilizers were diverted into

[1] Physical scientist, Division of Nonmetallic Minerals—Mineral Supply.

Table 1.—Salient phosphate rock statistics

(Thousand short tons and thousand dollars)

	1969	1970	1971	1972	1973
United States:					
Mine production	121,712	125,514	127,752	126,651	139,713
Marketable production	37,725	38,739	38,886	40,831	42,137
Value	208,689	203,218	203,828	207,910	238,667
Average per ton	5.53	5.25	5.24	5.09	5.66
Sold or used by producers	36,730	38,765	40,291	43,755	45,043
Value	204,409	203,810	211,986	223,005	254,846
Average per ton	5.57	5.26	5.26	5.10	5.66
Exports [1]	11,336	11,738	12,587	14,275	13,875
P_2O_5 content	3,685	3,796	4,126	4,673	4,502
Value	62,288	59,980	64,841	75,376	82,983
Average per ton	5.49	5.11	5.15	5.28	5.98
Imports for consumption	140	136	84	55	65
Value	3,554	3,790	2,478	1,416	1,288
Average per ton	25.42	27.87	29.50	25.75	19.82
Consumption, apparent [2]	25,534	27,163	27,788	29,535	31,233
World: Production	88,930	93,635	r 92,508	r 98,981	e 108,060

e Estimate. r Revised.
[1] From table 5.
[2] Measured by sold or used plus imports minus exports.

the strong export market where prices were not controlled. Domestic demand was further strengthened when the U.S. Department of Agriculture released millions of additional acres in 1973 for cultivation. A further release of acreage was authorized for 1974 to stimulate an increase in agricultural exports and to bolster the U.S. balance of trade position. Without price relief prior to October 1973, the phosphate rock industry could not economically justify the investment necessary for new mines and plant expansions.

The pressures on the fertilizer industry increased in 1973 and on October 25, 1973, the Cost of Living Council exempted from Phase 4 controls the sale of fertilizers and nutrient materials used in the production of fertilizers. The Council also established a group composed of both industry and Government representatives to work toward increasing the supply of fertilizer to U.S. farmers by reducing exports. A system was implemented to monitor exports of fertilizer materials shipped under 1973 and 1974 contracts.[2]

The Environmental Protection Agency published proposed effluent limitations guidelines, and new source performance standards for the fertilizer industry.[3] They require achievement by not later than July 1, 1977, of effluent limitations for point sources, other than publicly-owned treatment works, by the application of the best practicable control technology currently available as defined by the Administrator pursuant to Section 304(b) of the Federal Water Pollution Control Act Public Law 92–500. Sec. 301(b) also requires achievement by not later than July 1, 1983, of effluent limitations for point sources, other than publicly-owned treatment works, by requiring the application of the best available technology economically achievable to result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants as determined in accordance with regulations issued by the Administrator pursuant to Sec. 304(b). The phosphate subcategory includes the manufacture of: Sulfuric acid by sulfur burning; wet-process phosphoric acid; normal superphosphate; triple superphosphate; and ammonium phosphate. The manufacture of phosphoric acid includes phosphate rock grinding, acid attack of phosphate rock, phosphoric acid concentration, and phosphoric acid clarification.

The program to study dewatering of Florida phosphate slimes, sponsored by the U.S. Bureau of Mines and the industry-supported Florida Phosphate Council, was continued during 1973. The 1973 program is described in the technology section of this chapter.

Failure to issue mining permits in Hillsborough and Manatee Counties in Florida held up the development of two proposed mines in 1973. Brewster Phosphates was

[2] Cost of Living Council, Office of Public Affairs. Press Release, Oct. 25, 1973.
[3] Federal Register. Fertilizer Manufacturing Point Source Category: Proposed Effluent Limitations Guidelines. V. 38, No. 235, Part II, Dec. 7, 1973, pp. 33852–33860.

asked to resubmit mining plans and land reclamation programs in Hillsborough County. Beker Industries Corp.'s lease application in Manatee County was deferred after a 6-month moratorium was placed on the issuance of mining permits.

DOMESTIC PRODUCTION

Domestic production of marketable phosphate rock was 42,137,000 tons, an increase over that of 1972 of 1,306,000 tons or 3.2%. The value of the marketable rock was $238,667,000, an increase of 14.8% over that of 1972. The average grade of phosphate ore mined in the United States was 13.6% P_2O_5, and the average grade of marketable rock was 31.1% P_2O_5. The average weight recovery of concentrate and rock marketable as mined was 30.2%, and the P_2O_5 recovery averaged 68.9%. Of the total marketable production in the United States, Florida and North Carolina produced 34,427,000 tons (81.7%), the Western States produced 5,198,000 tons (12.3%), and Tennessee produced 2,512,000 tons (6.0%).

Florida and North Carolina.—Production of marketable phosphate rock was 34,427,000 tons, an increase over that of 1972 of 306,000 tons or 0.9%. The value of marketable rock was $191,654,000, an increase of $17,744,000 over that of 1972 or 10.2%.

The average grade of phosphate ore mined was 12.8% P_2O_5, and the average grade of marketable rock was 31.9% P_2O_5. The average weight recovery of concentrate and rock marketable as mined was 27%, and the average P_2O_5 recovery was 67.3%. The production capacity of Florida and North Carolina phosphate mines was limited in 1973 to less than 34.5 million tons of marketable rock. This capacity is less than various estimates made in prior years when the pressures to produce were much less, and power interruptions, limited time and capital to accomplish repair and maintenance, and lower grade ores were not factors influencing plant operations and production.

Agrico Chemical Co., Borden, Inc., Brewster Phosphates, Gardinier, Inc., W. R. Grace & Co., International Minerals & Chemical Corp., Mobil Oil Corp., Poseidon Mines, Inc., P.S.A. Enterprises, Occidental Petroleum Corp., U.S.S. Agri-Chemicals, Inc., and Swift Chemical Co. produced marketable rock from Florida land-pebble phosphate fields. Howard Phosphate Co., Kellogg Co., Loncala Phosphate Co., and Manko, Inc. mined 22,000 tons of soft rock in Florida.

Texasgulf, Inc. mined and processed phosphate rock from deposits along the Pamlico River in North Carolina.

Agrico Chemical Co., a subsidiary of the Williams Co. of Tulsa, Okla., awarded contracts for a 400,000-ton-per-year P_2O_5 phosphoric acid plant and a 100-ton-per-hour single train diammonium phosphate granulation plant at Fausta, La. and an 80-ton-per-hour granular triple superphosphate plant in South Pierce, Fla.[4] A contract was also awarded to construct two 1,800-ton-per-day capacity sulfuric acid plants at South Pierce, Fla.[5] Contracts were awarded for plants to produce 1,000 tons per day of ammonia and 1,800 tons per day of urea ammonium nitrate solution at Verdigris, Okla.[6] A contract was awarded for a 1,000-ton-per-day urea plant at Blytheville, Ark.[7] Plans were advanced to open the Fort Green mine and construct a new plant to produce 3.5 million tons per year of marketable phosphate rock in Florida.

Beker Industries Corp., Greenwich, Conn., signed options to purchase from PPG Industries, Inc., Pittsburgh, Pa. 8,000 acres of phosphate reserves in eastern Manatee County, Fla. Beker plans to mine and ship about 3 million tons annually of marketable phosphate rock to their fertilizer operations in Illinois and Louisiana.[8] The company purchased a 100,000-ton-per-year ammonia plant in Iowa and will move the plant to Conda, Idaho. A 180,000-ton-per-year ammonia plant was purchased in Canada and will be relocated near Sarnia, Ontario, Canada. Another 200,000-ton-per-year ammonia plant was purchased in Illinois and will be moved to a Southwest U.S. location. With these ac-

[4] Chemical Engineering. V. 80, No. 15, June 25, 1973, p. 124.
[5] Fertilizer International. No. 52, October 1973, p. 8.
[6] Chemical Age International. V. 107, No. 2836, Nov. 23, 1973, p. 20.
[7] Chemical Marketing Reporter. V. 204, No. 15, Oct. 15, 1973, p. 4.
[8] Chemical Week. V. 113, No. 16, Oct. 17, 1973, pp. 24–25.

quisitions, Beker Industries will have a total capacity of 480,000 tons of anhydrous ammonia per year.

Conserve, Inc., started operating a modernized plant at Nichols, Fla., and this plant has the distinction of producing the first commercial monoammonium phosphate in the United States.[9]

CF Industries Inc. completed and dedicated a new phosphate terminal on Tampa Bay to ship about 500,000 tons of phosphatic fertilizers annually by water to farm cooperatives in the Midwest and Canada.[10] A new 800-ton-per-day P_2O_5 wet-process phosphoric acid plant will be constructed in Plant City, Fla. The facility is expected to be completed in 1974.

The Cities Service Co. sold its Tampa Agricultural Chemical Operations to Société des Participation Gardinier of Paris, France. The new name will be Gardinier, Inc.—U.S. Phosphoric Products.[11]

W. R. Grace & Co. announced plans to construct a 350,000-ton-per-year urea plant at Memphis, Tenn. The ammonia-producing capacity at this location was increased from 275,000 to 340,000 tons per year.[12] In addition, the agricultural chemical operations at Bartow, Fla., will be expanded with a 250,000-ton-per-year phosphoric acid plant and a 700,000-ton-per-year sulfuric acid plant.[13] Grace has ordered a 60-cubic yard dragline that will be used to mine rock from the Hooker's Prairie property in Polk County in 1977.

International Minerals & Chemical Corp. started construction of their 600,000-ton-per-year, P_2O_5-equivalent fertilizer plant near Bartow, Fla. They also acquired mining rights to 20 million tons of phosphate reserves in Florida.[14] The new washing plant at the Phosphoria mine is scheduled to start producing in 1974. The deslimed ore will be pumped 6 miles to the Noralyn recovery plant.

Occidental Petroleum Corp. purchased 24,000 acres of phosphate reserves from Owens-Illinois Inc. and Monsanto Co. The reserves, estimated by Occidental to be capable of supplying 23 million tons of marketable rock, are located near Occidental's Suwanee River phosphate mine and chemical complex.[15] A 45-cubic yard dragline was assembled at the Suwanee River Phosphate Division to increase production of phosphate rock. Expansion of the washing plant will increase capacity to about 3.5 million tons per year of marketable rock. An increase of 350,000 tons per year of P_2O_5 phosphoric acid capacity was announced for the Suwanee River complex. In addition, the diammonium phosphate capacity will be increased by 350,000 tons per year and a new but unspecified amount of sulfuric acid capacity will be added, all scheduled for operation in 1975. If the Occidental Petroleum Corp.'s trade agreement with the U.S.S.R. develops in 1978, an additional annual 3.5 million tons of marketable phosphate rock will be required to produce 1.1 million tons per year of superphosphoric acid.

A new sales office of the Phosphate Rock Export Assn. was opened in Paris, France at 42, Avenue Montaigne.[16]

The construction of a new phosphoric acid plant and sulfuric acid plant at Texasgulf, Inc.'s Lee Creek mine in North Carolina to increase the P_2O_5 capacity from 340,000 to 510,000 tons per year was completed. Work was started on the fourth phosphoric acid and sulfuric acid train to raise the plant capacity to 680,000 tons per year of P_2O_5. Mining and milling facilities will also be expanded to furnish phosphate rock for the acid plant and for merchant sales. A new terminal at Morehead City, N.C., will store 200,000 tons of phosphoric acid. On nearby Radio Island, a liquid sulfur terminal with a throughput of 600,000 tons per year was under construction.[17]

Western States.—Production of marketable phosphate rock was 5,198,000 tons, an increase of 643,000 tons over that of 1972, or 14.1%. This was the first full year of production for Agricultural Products Corp., and their contribution was a significant factor in the overall increase. The value of the marketable rock increased to $34,214,000 or 47% above that of 1972. The average grade of mined phosphate rock was 21.8% P_2O_5, and the average grade of marketable rock was 28.4% P_2O_5.

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[9] Chemical and Engineering News. June 11, 1973, pp. 21–22.
[10] The Tampa Tribune. Feb. 23, 1973.
[11] Phos Pholks. V. 9, No. 1, February 1973.
[12] Chemical Age International. V. 107, No. 2819, July 7, 1973, p. 6.
[13] Engineering and Mining Journal. V. 147, No. 6, June 1973, p. 267.
[14] Industrial Minerals. No. 69, June 1973, p. 41.
[15] The Tampa Tribune, Aug. 1, 1973.
[16] Industrial Minerals. No. 64, January 1973, p. 47.
[17] Texasgulf, Inc. 3rd Quarter Report. Oct. 5, 1973 4 pp.

The average grade of mine production used directly in electric furnaces was 26.4% P_2O_5, and the average beneficiated rock grade from washers and mills was 32.2% P_2O_5. It is of interest to note that of the total marketable production in the Western States, 34% was beneficiated and 66% was used directly. The weight recovery of the combined concentrates and rock used as mined was 62.9%, and the average P_2O_5 recovery was 82%.

Agricultural Products Corp., Monsanto Co., J. R. Simplot Co., and Stauffer Chemical Co. mined and processed phosphate rock in Idaho. In Montana, Cominco American, Inc., recovered phosphate rock from the underground Brock mine near Garrison. Stauffer Chemical Co. mined phosphate rock in Wyoming and in two areas in Utah. The Meramec Mining Co., Sullivan, Mo., again recovered apatite concentrate from Pea Ridge iron ore mine tailings.

Cominco American, Inc.'s Brock mine is projected to operate for at least another 10 years with a sustained production rate of 250,000 tons per year.[18] A new mine and adit about 3 miles south of the Brock adit called Warm Spring, will assure production at current levels and minimize operating problems at the Brock mine.

Agricultural Products, Inc.'s planned expansion program to double production capacity of diammonium phosphate at Conda, Idaho, was completed in 1973.

Stauffer Chemical Co. announced an expansion of its Vernal, Utah operation from 300,000 to 400,000 tons per year of phosphate rock. The grinding and railcar loading facilities at Phoston, Utah, will be enlarged to handle the additional tonnage from the Vernal mine.

Tennessee.—Production of marketable phosphate rock was 2,512,000 tons, an increase of 358,000 tons or 16.6% greater than that of 1972. The value of the marketable rock also increased 19.3% over that of 1972.

The average grade of the mined ore was 21.5% P_2O_5, the average weight recovery of concentrates was 60.3%, and recovery of P_2O_5 averaged 73%.

Hooker Chemical Corp., Monsanto Co., Stauffer Chemical Co., and the Tennessee Valley Authority (TVA) mined phosphate rock in Tennessee and reduced the rock in electric furnaces to elemental phosphorus.

Stauffer Chemical Co. plans to double the capacity to produce benzene phosphorus dichloride and benzene phosphorus thio-dichloride at its Mt. Pleasant, Tenn., organic chemicals plant.

TVA will implement a plan to eliminate phosphate mining; production of phosphorus, phosphoric acid, and nitric acid; and the operation of one rather than two granulation plants between 1973 and 1975.[19]

[18] Engineering and Mining Journal. Brock Feeds Phosphates to Fertilizer Plants. V. 174, No. 9, September 1973, pp. 146–147.

[19] Chemical Marketing Reporter. V. 203, No. 15, Apr. 9, 1973, pp. 4 and 39.

Table 2.—Production of phosphate rock in the United States, by State

(Thousand short tons and thousand dollars)

	Mine production		Mine production used directly		Washer production		Marketable production		
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Value
1972:									
Florida [1]	117,263	16,289	20	4	34,101	10,980	34,121	10,984	173,910
Tennessee	3,824	817	W	W	W	W	2,154	563	10,732
Western States [2]	5,565	1,450	3,199	860	1,356	432	4,555	1,292	23,268
Total [3]	126,651	18,557	3,219	864	35,457	11,412	40,831	12,839	207,910
1973:									
Florida [1]	127,283	16,319	22	4	34,405	10,972	34,427	10,977	191,654
Tennessee	4,168	894	W	W	W	W	2,512	653	12,799
Western States [2]	8,263	1,800	3,412	901	1,786	576	5,198	1,477	34,214
Total [3]	139,713	19,013	3,434	905	36,191	11,548	42,137	13,106	238,667

W Withheld to avoid disclosing individual company confidential data.
[1] Includes North Carolina.
[2] Includes Idaho, Missouri (1973), Montana, Utah, and Wyoming.
[3] Data may not add to totals shown because of independent rounding.

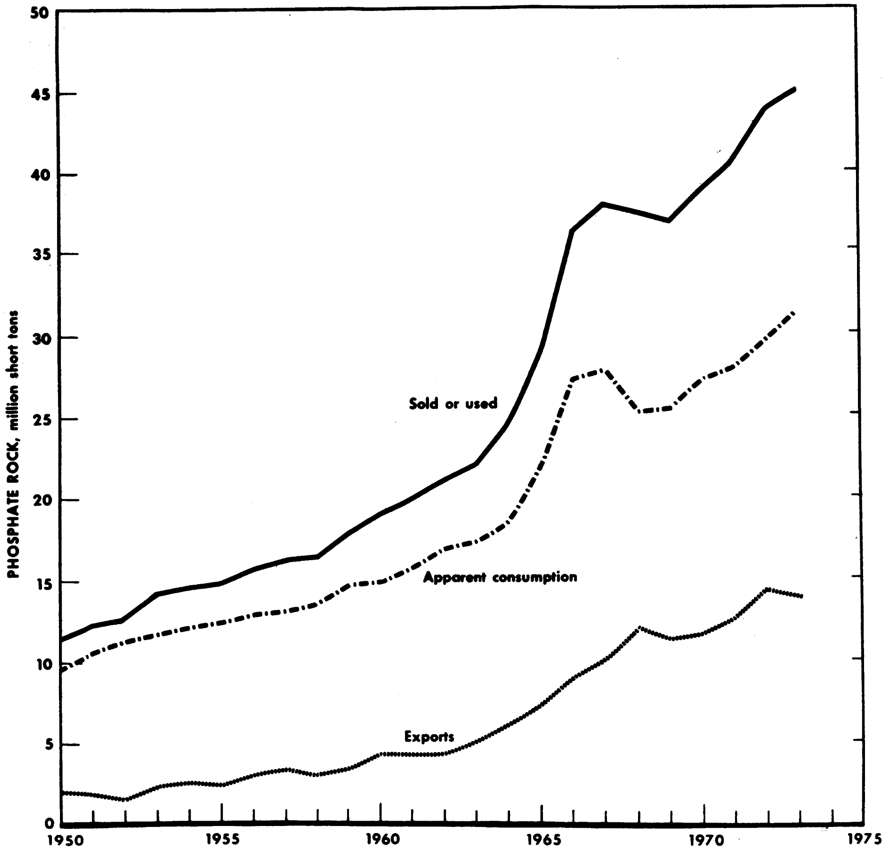

Figure 1.—Phosphate rock (sold or used), apparent consumption, and exports.

CONSUMPTION AND USES

Apparent consumption of marketable phosphate rock increased 5.7% above that reported in 1972. According to producers' reports, the quantity of marketable rock sold or used was 45,043,000 tons. This was an increase of 2.9% over the quantity sold or used in 1972. The domestic market consumed 69% of this total and 31% was exported.

The consumption pattern in the United States was 25,124,000 tons (80.6%) for fertilizer, 5,762,000 tons (18.5%) for elemental phosphorus production, and 282,000 tons (0.9%) was used to produce defluorinated rock and for other purposes.

The percent distribution by grade of marketable rock consumed in the United States is compared with the percent distribution in 1972 in the following tabulation:

Grade, percent BPL [1]	1972 percent distribution	1973 percent distribution
Less than 60	9.5	8.7
60–66	6.3	11.9
66–70	40.5	40.9
70–72	10.3	12.3
72–74	22.1	16.7
Over 74	11.3	9.5

[1] 1.0% BPL (bone phosphate of lime or tricalcium phosphate) = 0.458% P_2O_5.

Florida and North Carolina.—The quantity of phosphate rock sold or used decreased slightly, from 36,934,000 tons in 1972 to 36,916,000 tons in 1973. Of this total sold or used in 1973, 63% was consumed in the domestic fertilizer market and the balance, 37%, exported with a minor quantity used domestically in other applications. The consumption pattern of the overall domestic fraction was 23,421,000 tons (98.6%) for fertilizer, with the balance converted into elemental phosphorus, defluorinated rock, and other minor applications.

The percent distribution by grade of marketable rock sold or used from Florida and North Carolina is compared in the following tabulation for 1972 and 1973:

Grade, percent BPL	1972 percent distribution	1973 percent distribution
Less than 60	0.1	0.3
60–66	5.1	9.7
66–70	44.8	45.9
70–72	11.2	14.1
72–74	25.5	18.5
Over 74	13.3	11.5

Western States.—The quantity of marketable rock sold or used increased 19.2% compared with the quantity sold or used in 1972. Of the total sold or used in the domestic and export markets, about 45% was used for agricultural purposes. The consumption pattern in the domestic market was 35.5% used in fertilizer production and 64.5% was used in electric furnaces. The distribution by grade was 37.7% less than 60% bone phosphate of lime (BPL), 60.5% less than 66% BPL, and the balance was distributed in higher grades.

Tennessee.—The quantity of marketable rock sold or used increased from 2,240,000 tons in 1972 to 2,665,000 tons in 1973, a 19.0% improvement. All of this rock was consumed in domestic electric furnaces to produce elemental phosphorus and industrial chemicals. Most of the elemental phosphorus was burned to produce furnace phosphoric acid which was used to produce sodium tripolyphosphate and dicalcium phosphate. A small amount of elemental phosphorus was used to produce anhydrous derivatives.

Table 3.—Phosphate rock sold or used by producers in the United States, by grade and State in 1973

(Thousand short tons and thousand dollars)

Grade—BPL [1] content (percent)	Rock	P_2O_5 content	Value	Rock	P_2O_5 content	Value
	Florida and North Carolina			Tennessee		
Below 60	99	25	494	W	W	W
60–66	3,566	1,009	16,307	W	W	W
66–70	16,955	5,262	89,045	W	W	W
70–72	5,222	1,695	29,897	--	--	--
72–74	6,813	2,264	38,238	W	W	W
Plus 74	4,262	1,465	31,501	W	W	W
Total [2]	36,916	11,720	205,482	2,665	699	13,812
	Western States			Total United States		
Below 60	W	W	W	3,926	972	17,011
60–66	W	W	W	5,336	1,507	26,473
66–70	W	W	W	18,414	5,717	100,165
70–72	330	106	2,624	5,552	1,801	32,522
72–74	W	W	W	7,522	2,500	46,958
Plus 74	30	10	W	4,293	1,476	31,718
Total [2]	5,462	1,552	35,551	45,043	13,972	254,846

W Withheld to avoid disclosing individual company confidential data.
[1] Bone phosphate of lime $Ca_3(PO_4)_2$.
[2] Data may not add to totals shown because of independent rounding.

Table 4.—Phosphate rock sold or used by producers, by use and State

(Thousand short tons)

Use	Florida [1]		Tennessee		Western States		Total [2] United States	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1972								
Domestic:								
Agricultural	23,174	7,356	--	--	1,130	361	24,304	7,716
Industrial	W	W	2,240	587	W	W	5,176	1,364
Total	23,174	7,356	2,240	587	1,130	361	29,480	9,080
Exports	W	W	--	--	W	W	14,275	4,673
Total	36,934	11,868	2,240	587	4,581	1,299	43,755	13,753
1973								
Domestic:								
Agricultural	23,701	7,421	15	5	1,688	544	25,404	7,969
Industrial	W	W	2,649	694	W	W	5,764	1,501
Total [2]	23,701	7,421	2,665	699	1,688	544	31,168	9,470
Exports	W	W	--	--	W	W	13,875	4,502
Total	36,916	11,720	2,665	699	5,462	1,552	45,043	13,972

W Withheld to avoid disclosing individual company confidential data; included in "Total United States."
[1] Includes North Carolina.
[2] Data may not add to totals shown because of independent rounding.

Table 5.—Phosphate rock sold or used by producers in the United States, by use

(Thousand short tons)

Use	1972		1973	
	Rock	P_2O_5 content	Rock	P_2O_5 content
Domestic:				
Fertilizers	[r] 24,018	[r] 7,620	25,124	7,876
Elemental phosphorus	5,173	1,363	5,762	1,500
Defluorinated rock Other uses	289	97	282	94
Total	29,480	9,080	31,168	9,470
Exports	14,275	4,673	13,875	4,502
Grand total	43,755	13,753	45,043	13,972

[r] Revised.

Table 6.—Florida phosphate rock sold or used by producers, by type

(Thousand short tons and thousand dollars)

Year	Land pebble [1]				Soft rock				Total [2]			
	Rock	P_2O_5 content	Value		Rock	P_2O_5 content	Value		Rock	P_2O_5 content	Value	
			Total	Average per ton			Total	Average per ton			Total	Average per ton
1969	28,835	9,307	155,197	$5.38	30	6	221	$7.34	28,865	9,313	155,418	$5.38
1970	31,111	9,981	157,652	5.07	24	5	168	7.10	31,134	9,986	157,820	5.07
1971	33,176	10,621	173,950	5.24	20	4	141	7.19	33,195	10,625	174,091	5.24
1972	36,913	11,863	188,205	5.10	21	4	121	5.87	36,934	11,868	188,326	5.10
1973	36,894	11,716	205,328	5.57	22	4	154	7.00	36,916	11,720	205,482	5.57

[1] Includes North Carolina.
[2] Data may not add to totals shown because of independent rounding.

Table 7.—Tennessee phosphate rock sold or used by producers

(Thousand short tons and thousand dollars)

Year	Rock	P_2O_5 content	Value	
			Total	Average per ton
1969 [1]	3,193	851	18,192	$5.70
1970 [1]	3,184	864	15,606	4.90
1971	2,596	687	12,281	4.73
1972	2,240	587	11,188	4.99
1973	2,665	699	13,812	5.18

[1] Includes Alabama.

STOCKS

Although the phosphate rock mining companies in Tennessee and the Western States do not inventory stocks of marketable rock on an annual basis, the companies in Florida and North Carolina maintain substantial stocks of marketable rock to insure an uninterruptable feed for the fertilizer plants. It is recognized that stocks are accumulated in the Western States during the mild months of the year, when weather conditions permit mining and transportation to consuming electric furnace and fertilizer plants. These stocks are depleted during the winter months. Stocks are not maintained in Tennessee.

In Florida and North Carolina, yearend stocks of marketable phosphate rock declined from 10,501,000 tons in 1972 to 8,482,000 tons in 1973, a decrease of 19.2%. The decline in yearend stocks from 1971 to 1972 was 12%. The significant decline in stocks during 1973 further emphasized the difficulty that the industry experienced in attempting to satisfy demand.

PRICES

The December 10, 1973, issue of the Chemical Marketing Reporter listed prices for various grades of Florida land-pebble phosphate rock. They have not changed since 1971 and are published only as an indication of price levels in 1973. Actual prices negotiated for Florida and North Carolina phosphate rock are not published. The price of phosphate rock produced in Tennessee and the Western States also is not published. Most of this rock is consumed by the producing companies, converted into intermediates or end products, and then marketed.

The average 1973 unit value [20] of marketable rock reported by producers was $5.66 per short ton f.o.b. plant, an increase from the $5.09 per ton value reported in 1972.

The average unit value reported for marketable rock sold or used in the domestic market from Florida and North Carolina increased from $5.10 per ton in 1972 to $5.57 per ton in 1973. In the Western States, the unit value of marketable rock sold or used increased from $5.13 per ton in 1972 to $6.51 per ton in 1973. The unit value of marketable rock sold or used in Tennessee increased slightly from $4.99 per ton in 1972 to $5.18 per ton in 1973.

The average unit value of marketable phosphate rock exported from the United States increased from $5.28 per ton in 1972 to $5.98 per ton in 1973. The unit value of marketable rock exported from Florida and North Carolina increased from $5.10 per ton in 1972 to $5.77 per ton in 1973. The unit value of phosphate rock exported from the Western States increased from $8.76 per ton in 1972 to $9.93 per ton in 1973. Tennessee rock was not exported.

The Phosphate Rock Export Association, Tampa, Fla., publishes export prices. After one price increase on July 1, 1972, the Association issued a new export price schedule on October 1, 1973, that was to be effective on January 1, 1974. This price schedule was superseded on November 16,

[20] Value, if sold, net selling price f.o.b. plant, or if used, estimated value from comparable selling prices or developed price, that is, cost plus overhead and profit.

1973, when a new price schedule was published to take effect on January 1, 1974. The trends in published export prices are shown in the following tabulation with prices converted to a short ton f.o.b. plant basis:

BPL base	Effective date		
	July 1, 1972 [1]	January 1, 1974 [2]	January 1, 1974 [3]
66	--	$9.40	$14.40
68	$6.24	9.94	16.19
70	--	10.92	17.98
72	7.42	11.72	19.76
73	7.67	12.35	21.10
75	8.45	13.69	22.89
77	9.44	15.29	25.12

[1] Issued April 1, 1972.
[2] Issued October 1, 1973; canceled on November 16, 1973. Superseded by schedule issued on November 16, 1973.
[3] Issued November 16, 1973.

The Office Cherifien des Phosphates raised the prices of all grades of Moroccan phosphate rock in October 1973. The new prices were to become effective January 1, 1974. The announced prices, converted to U.S. dollars per short ton, are as follows:

Grade, BPL base	f.o.b. vessel Casablanca
70	$34.82
72	37.01
75	38.83
77 (calcined)	43.59
80	46.08

The stability of these new price levels is not clear at this time, however, it appears that the world demand for phosphate rock is sufficiently strong to support these prices.

The Cost of Living Council removed price controls on phosphate rock in October 1973. Domestic prices of phosphate rock published by several producers after price controls were lifted showed that new contracts for phosphate rock in the domestic market will have prices similar to export prices.

Table 8.—Phosphate rock, Florida land-pebble, run of mine washed, dried, unground, bulk carlots, f.o.b. mine

(Per short ton)

Grade, percent BPL	Price range
66–68	$ 6.50– --
68–70	5.84–$ 7.50
70–72	6.50– 10.65
74–75	7.55– 9.20
76–77	10.20– --

Source: Chemical Marketing Reporter. Apr. 16, 1973, p. 13.

FOREIGN TRADE

Industry reported that 13,875,000 tons of marketable phosphate rock was exported in 1973, 400,000 tons less than that exported in 1972. Although most of the phosphate rock was exported from Florida, Florida exports declined from 1972 levels by 3% in 1973. Exports from the Western States to Canada were essentially unchanged in 1973 from those reported in 1972.

The average calculated unit value of exported phosphate rock increased from $5.28 per ton in 1972 to $5.98 per ton in 1973.

Analysis of import data showed that 65,025 tons of phosphate rock was imported in 1973 compared with 54,738 tons in 1972, an increase of 18.8%. Imports of 1,456 tons and 37,143 tons of low-fluorine phosphate rock were received from Mexico and the Netherlands Antilles, respectively. Shipments of 12,727 tons and 13,699 tons were also received from Spanish Sahara and Morocco, respectively. The value of total imports was $1,288,000, and the average unit value was $19.82 per ton.

Table 9.—U.S. exports of phosphate rock, by country
(Thousand short tons and thousand dollars)

Destination	1972 Quantity	1972 Value	1973 Quantity	1973 Value
Florida phosphate rock:				
Austria	147	938	148	1,295
Belgium-Luxembourg	732	4,544	958	6,254
Brazil	791	5,867	639	5,288
Canada	2,205	16,492	2,737	20,075
Chile	55	483	78	664
China, People's Republic of	--	--	41	451
Colombia	31	229	111	857
Ecuador	7	59	8	78
El Salvador	12	78	5	52
France	497	3,904	487	3,769
Germany, West	1,455	8,965	1,241	7,868
India	454	2,994	252	1,768
Iran	415	2,965	331	2,703
Italy	864	5,962	601	4,049
Japan	2,220	20,449	2,165	21,777
Korea, Republic of	574	3,974	622	4,456
Mexico	785	5,058	1,071	8,150
Netherlands	715	4,248	599	3,557
Peru	9	70	13	120
Philippines	126	945	173	1,308
Poland	--	--	125	919
Romania	421	2,770	147	1,249
Spain	r 311	r 2,149	163	1,194
Sweden	86	563	93	678
Taiwan	82	760	93	1,130
United Kingdom	54	353	151	1,112
Uruguay	40	484	24	272
Other	34	257	1	18
Total	13,122	95,560	13,077	101,111
Other phosphate rock: [1]				
Brazil	3	22	1	80
Canada	741	10,001	742	10,573
Costa Rica	(2)	5	6	65
El Salvador	--	--	10	109
Germany, West	1	30	1	23
Japan	--	--	9	109
Mexico	76	753	(2)	3
Netherlands	(2)	7	8	63
Norway	42	289	73	584
Peru	--	--	5	508
Venezuela	1	68	(2)	14
Vietnam, South	6	625	--	--
Other	(2)	78	(2)	53
Total	870	11,878	855	12,184
Grand total	13,992	107,438	13,932	113,295

r Revised.
[1] Includes colloidal and sintered matrix, Tennessee, Idaho, Montana and soft phosphate rock.
[2] Less than ½ unit.

Table 10.—U.S. exports of superphosphates, by country

(Thousand short tons and thousand dollars)

Destination	1972		1973	
	Quantity	Value	Quantity	Value
Algeria	14	911	34	2,904
Argentina	17	1,010	21	1,508
Australia	2	255	1	43
Bangladesh	39	3,050	41	3,253
Brazil	489	25,441	341	24,996
Canada	83	4,416	42	2,827
Chile	68	3,405	44	3,419
Colombia	18	855	40	3,016
Costa Rica	13	702	9	684
Dominican Republic	13	716	14	1,055
Ecuador	3	208	10	642
Egypt	--	--	9	756
France	8	355	70	3,768
Germany, West	1	63	10	695
Guatemala	1	50	3	93
Guyana	6	205	3	137
Hong Kong	1	80	1	69
Indonesia	83	5,174	22	1,765
Italy	37	2,008	19	1,219
Jamaica	4	207	4	192
Japan	18	974	25	1,763
Korea, Republic of	--	--	82	7,503
Mexico	6	76	1	96
Netherlands	16	840	2	137
Nicaragua	(1)	29	(1)	12
Peru	(1)	38	4	402
Singapore	20	1,051	101	6,929
Sri Lanka (Ceylon)	--	--	6	425
Venezuela	1	80	5	329
Other	6	266	3	353
Total	967	52,465	967	70,990

[1] Less than ½ unit.

Table 11.—U.S. exports of ammonium phosphates, by country

(Thousand short tons and thousand dollars)

Destination	1972		1973	
	Quantity	Value	Quantity	Value
Afars and Issas	12	1,202	--	--
Afghanistan	--	--	12	1,326
Algeria	--	--	45	3,881
Argentina	42	3,071	41	3,992
Belgium-Luxembourg	23	1,512	16	1,321
Bolivia	1	79	5	599
Brazil	512	34,235	442	38,616
Canada	57	3,250	45	3,208
Chile	2	139	120	9,883
China, People's Republic of	--	--	48	4,736
Colombia	43	3,044	39	3,359
Costa Rica	29	2,078	30	2,986
Dominican Republic	20	1,525	23	2,057
Ecuador	13	923	14	1,451
El Salvador	34	2,313	36	3,066
Ethiopia	11	815	27	2,722
France	78	4,843	120	9,104
Greece	12	950	--	--
India	298	19,566	399	30,384
Indonesia	--	--	11	701
Italy	271	18,029	98	7,793
Japan	26	1,556	107	9,228
Lebanon	52	4,339	68	6,140
Netherlands	27	1,970	--	--
New Zealand	9	641	33	2,687
Nicaragua	2	180	24	2,181
Norway	--	--	19	573
Pakistan	84	7,690	232	21,627
Peru	2	163	9	667
Philippines	--	--	11	860
Singapore	16	1,381	2	243
Switzerland	--	--	12	793
Thailand	3	145	43	3,535
Uruguay	3	221	13	1,274
Venezuela	--	--	6	537
Vietnam, South	27	2,717	18	1,906
Yugoslavia	89	6,457	55	4,574
Other	18	r 1,015	12	1,054
Total	1,816	r 126,049	2,235	189,064

r Revised.

Table 12.—U.S. exports of mixed chemical fertilizers, by country

(Thousand short tons and thousand dollars)

Destination	1972		1973	
	Quantity	Value	Quantity	Value
Argentina	1	56	(1)	5
Belgium-Luxembourg	45	1,211	7	247
Brazil	11	1,173	2	1,086
Canada	61	4,601	72	5,630
Colombia	7	537	29	2,139
El Salvador	7	415	9	587
France	5	270	(1)	22
Germany, West	3	805	4	1,070
Greece	(1)	73	1	248
Guatemala	1	197	3	307
India	17	2,136	--	--
Italy	8	401	20	1,085
Japan	(1)	60	(1)	407
New Zealand	18	966	12	729
Panama	1	110	3	327
Sweden	13	781	23	814
Thailand	1	85	13	1,288
United Kingdom	(1)	29	22	838
Vietnam, South	157	12,498	130	14,714
Other	11	1,315	25	2,541
Total	367	27,719	375	34,084

[1] Less than ½ unit.

Table 13.—U.S. exports of elemental phosphorus, by country

(Thousand short tons and thousand dollars)

Destination	Quantity	Value
Argentina	2	1,095
Australia	1	1,478
Germany, West	(1)	206
Japan	1	404
Mexico	21	8,427
United Kingdom	(1)	445
Other	2	201
Total	27	12,256

[1] Less than ½ unit.

Table 14.—U.S. imports for consumption of phosphate rock and phosphatic fertilizers

(Thousand short tons and thousand dollars)

Fertilizer	1972		1973	
	Quantity	Value	Quantity	Value
Phosphates, crude and apatite	[1] 55	[1] 1,416	[1] 65	[1] 1,288
Phosphatic fertilizers and fertilizer materials	70	3,184	68	3,042
Ammonium phosphates, used as fertilizers	501	31,070	393	27,290
Bone ash, bone dust, bone meal and bones ground, crude or steamed	6	484	13	1,374
Dicalcium phosphate	20	976	3	175

[1] Adjusted by the Bureau of Mines.

WORLD REVIEW

The majority of world phosphate rock production, with the exception of that from the United States, is from Government-owned operations in more than 30 countries.

Angola.—The Companhia de Fosfatos de Angola, which has been seeking financial support for exploitation of phosphate deposits in Cabinda, has reportedly ceased operations. Recent assays have indicated that the phosphate deposits in the company's concession area are not of commercial value. Since this contradicts previous assay reports, the company is in need of additional financial backing for further exploration, but this has not been secured.[21]

Australia.—Potential importers of phosphate rock from the projected Broken Hill South, Ltd. operation are showing interest in the company's progress. Although trials at the Lady Annie pilot plant started in April of this year, it will take several years or longer to develop sufficient production to satisfy the demand from Australia and the Oceania area and also reach levels to permit exporting significant quantities. The question of transport to the Gulf of Carpentaria has to be resolved. A pipeline to move phosphate rock slurry, coupled with a drying plant at the port, has been proposed. The cost of transporting in a pipeline, drying, and port costs will have a strong influence on the f.o.b. vessel price, but in light of the worldwide short supply condition, this is an opportune time to consider this development.[22]

China, The People's Republic of.—According to a study made by the British Sulphur Corp., Ltd., production of phosphate rock will increase from an equivalent 1,290 thousand tons of P_2O_5 in 1973 to an equivalent 2,629 thousand tons of P_2O_5 in 1980.[23]

Egypt, Arab Republic of.—The Abu Tartur phosphate deposits in the Western Desert were estimated to contain reserves of the order of 600 million tons. Mr. Rushdi Saeed, Chairman of the Egyptian Geological Survey and Mining Authority, confirmed the reserves to be 1,000 million tons. If plans materialize in 1979, 10 million tons of concentrates ranging from 72 to 74 BPL will be shipped from this deposit.[24]

India.—The State Government of Rajasthan purchased all outstanding shares in Bikaner Gypsums, Ltd. and it is now a wholly-owned Government company. In 1969, the company was appointed by the Government as the principal mining contractor for phosphate rock deposits in Rajasthan and a production goal of 4,000 tons per day was established for 1974. The Government action was probably taken because of the company's failure to increase its output.

A feasibility report prepared by Parsons Jurden Corp. for the World Bank indicates the phosphate rock deposits discovered near Udaipur are very substantial. A production rate of 1.5 million tons per year of plus 30% P_2O_5 product was recommended.[25]

Israel.—The Arad phosphoric acid plant constructed by the Israeli Government and the Madera Corp. of the United States was shutdown because of fundamental construction problems. The Israeli Government now controls the plant and will determine its future. The original design capacity in 1971 was 183,000 tons per year of P_2O_5. Only 13,000 tons per year has been produced to date.[26]

Jordan.—Because the Lebanon-Syria border was closed early in the year, phosphate rock exports from Jordan were reduced and were estimated to be about 1.3 million tons. Jordan Phosphate Mines Co., Ltd. operates open pit mines at Ruseifa and El Hasa. At El Hasa, an expansion program will raise the country's output to 2 million tons annually.[27]

Morocco.—Preliminary indications are that Morocco produced 18.2 million short tons of phosphate rock and the amount sold or used exceeded 18.8 million short tons. The 1973–77 expansion plan has not been detailed; however, production goals of 26 million annual tons by 1977 and 30 million annual tons in 1980 has been suggested. New open pit mines are planned at Benguerir and Sidi Haggaj. The Office Cherifien des Phosphates hopes to double underground production at Youssoufia to 6 million tons per year. Ore mined from a depth of 166 feet will be calcined to improve the grade from 68% to 75% BPL. A pilot calcination plant is under construction. The Khouribga complex produces about 80% of Morocco's phosphate rock from open pit mines at Sidi Daoui and Merra el-Arech. Layer 2 ore at Sidi Daoui is beneficiated to 72% BPL in a 3–4 million ton-per-year washing plant. Layer 2 at

[21] U.S. Consulate, Luanda, Angola. State Department Airgram A–41, June 7, 1973, 10 pp.
[22] Fertilizer International. No. 49, July 1973, p. 2.
[23] Chemical Age International. V. 107, No. 2824, Aug. 31, 1973, p. 14.
[24] Engineering and Mining Journal. V. 174, No. 5, May 1973, p. 17.
[25] Mining Journal. V. 280, No. 7191, June 15, 1973, p. 500.
[26] Industrial Minerals. January 1973, p. 41. No. 64.
[27] Bureau of Mines. Mineral Trade Notes. V. 70, No. 12, December 1973, p. 29.

Merra el-Arech will be processed through a new pilot calcination plant and dry enrichment plant to 78% and 72% BPL products. Future additions to these treatment facilities is contingent on the profitability of these pilot projects.[28]

New Zealand.—Because the high-grade deposits of phosphate rock in the Pacific Islands are likely to be exhausted by 1982, a major search for phosphate rock is underway in New Zealand. Warrants for prospecting near Waibouaiti and Palmerston in North Otago have been granted to Australasian Mining and Oil Investments, Ltd. They have also applied for warrants to prospect at Waihao Downs, near South Canterbury.[29]

Spanish Sahara.—Some shipments were made from the Fosfatos de Bu-Craa S.A. mine in 1973 but they were substantially less than the projected 3.3 million short tons. Startup problems with the ore preparation plant and a new desalinization plant were the principal reasons. Although construction has started on an expansion to increase production to 6.6 million, it is

[28] Bureau of Mines. Mineral Trade Notes. V. 70, No. 10, October 1973, pp. 23–29.
[29] Feed and Farm Supplies. V. 69, No. 6, June 1972. p. 22.

Table 15.—Phosphate rock: World production by country

(Thousand short tons)

Country [1]	1971	1972	1973 [p]
North America:			
United States	38,886	40,831	42,137
Mexico	64	69	77
Netherlands Antilles	[2] 172	123	102
South America:			
Argentina (guano)	1	[e] 1	[e] 1
Brazil	220	260	276
Chile (guano)	14	17	[e] 18
Colombia	11	7	11
Peru (guano)	25	[e] 25	[e] 25
Venezuela	28	33	33
Europe:			
France (phosphatic chalk)	21	20	39
Germany, West	66	83	103
U.S.S.R. [e]	[r] 20,950	[r] 21,750	23,400
Africa:			
Algeria	546	580	710
Egypt, Arab Republic of	786	620	606
Morocco	13,237	16,503	18,259
Rhodesia, Southern	116	121	165
Senegal:			
Aluminum phosphate	162	183	[e] 218
Calcium phosphate	1,541	1,378	[e] 1,648
Seychelles Islands (guano) [e]	8	8	8
South Africa, Republic of [3]	1,359	1,380	1,505
Spanish Sahara	--	165	768
Togo	1,891	2,126	2,527
Tunisia	3,485	3,734	3,828
Uganda (apatite)	18	17	17
Asia:			
China, People's Republic of [e]	2,400	2,900	3,300
Christmas Island (Indian Ocean)	1,092	1,269	1,695
India:			
Apatite	12	13	11
Phosphate rock	256	239	149
Israel	843	962	698
Jordan	627	765	1,219
Korea, North (apatite) [e]	300	330	400
Philippines:			
Guano	1	2	[e] 2
Phosphate rock	5	3	[e] 3
Syrian Arab Republic	7	124	165
Vietnam, North [e]	610	[r] 310	550
Oceania:			
Australia	[r] 7	1	6
Nauru Island	2,058	1,474	2,561
Ocean Island	683	555	820
Total	[r] 92,508	98,981	108,060

[e] Estimate. [p] Preliminary. [r] Revised.
[1] In addition to the countries listed, Belgium, Indonesia, and Tanzania produce phosphate rock, and South West Africa produces guano, but information is inadequate to make reliable estimates.
[2] Exports.
[3] Revised from crude phosphate basis reported in previous editions to marketable phosphate basis as reported by International Superphosphate Manufacturers Association.

not certain that this production level can be attained by 1975.

Togo.—To meet the expected increase in world phosphate demand in the next few years, Cie. Togolaise des Mines du Bénin (CTMB) will increase production to 2.4 million tons per year and will open a new mine at Kpogame in 1973. The Togolese Government increased its share in CTMB from 20% to 35%. W. R. Grace & Co.'s share declined to 28%, and the French interests declined to 37%. The Government plans to acquire a majority interest by 1987.[30]

U.S.S.R.—Although a comprehensive understanding of new phosphate rock activity in the U.S.S.R. is not readily available, two developments appear noteworthy. On the Kola Peninsula in the North, commercial exploitation of the Koashvinsky deposit has started. Reserves of 500 million tons were reported. About 90% of the phosphate fertilizers produced in the U.S.S.R. use apatite from the Khibiny Mountains on the Kola Peninsula. The incremental production expected from this new deposit was not reported.[31]

Chilisaisk in West Kazakhstan is scheduled to become the third largest mining area in the U.S.S.R. after the Kola area and Karatau in Kazakhstan. Production from Chilisaisk in 1973 was 300,000 tons and in 1975, production will increase to 1,100,000 tons.[32]

A review of available data on the Soviet phosphate rock industry indicates that figures published by the Bureau of Mines in recent years should be revised downward. Corrected figures for 1971 and 1972 have been incorporated in the world production table; corresponding estimates for 1964 to 1970 are as follows, in thousand short tons: 1964—11,750; 1965—14,850; 1966—15,000; 1967—15,150; 1968—16,550; 1969—18,000; 1970—19,600.

[30] Industrial Minerals. No. 72, September 1973, p. 34.
[31] Chemistry and Industry. V. 15, No. 18, Sept. 15, 1973, p. 861.
[32] European Chemical News. V. 23, No. 581, Apr. 27, 1973, p. 14.

TECHNOLOGY

As part of a continuing research program to expand its nitrophosphate technology, the Norwegian company Norsk Hydro A/S has developed a method of manufacturing phosphoric acid from mother liquor obtained after crystallization of calcium nitrate from the solution formed when phosphate rock is acidulated with nitric acid.[33]

Uranium Recovery Corp. has announced the construction of a uranium separation plant that will go onstream in 1975. It will be located in Polk County, close to a number of phosphate mining and chemical plants. Uranium recovery systems will be located at several phosphoric acid plants in the area. Details of the process have not been disclosed but it is known that an organic solvent will be used to extract the uranium values which will then be transported to the central processing plant for refining. Research work on the recovery of uranium from wet process phosphoric acid manufactured from Florida rock was carried out at the Oak Ridge National Laboratory, Oak Ridge, Tenn. A solvent di (two-ethylhexyl) -phosphoric acid and trictylphosphine in a high-boiling aliphatic diluent is used to extract uranium values from the phosphoric acid. The solution is then contacted with phosphoric acid containing ferrous ions to reduce the uranium to the trivalent state in which it is less soluble in the organic solvent and therefore returns to the aqueous phase. The phosphoric acid used in this stage is part of the raffinate from the extraction stage. The tetravalent uranium is then oxidized back to the hexavalent state by bubbling in air or by addition of sodium chlorate, and is then extracted a second time with the same organic solvent. It is finally recovered from the organic solution, with an overall yield of about 95%, by stripping with an aqueous ammonia carbonate solution. Ammonium uranyl tricarbonate is precipitated and after filtration is calcined.[34]

The Albany Metallurgy Research Center, U.S. Bureau of Mines, Albany, Oreg., continued work on a project to demonstrate the feasibility and costs of manufacturing

[33] The British Sulphur Corp., Ltd. Phosphoric Acid Manufacture. No. 64, March/April 1973, p. 43.
[34] The British Sulphur Corp., Ltd. Phosphate Rock Processing. No. 66, July/August 1973, p. 47.

phosphoric acid by acidulating Florida phosphate matrix with sulfuric acid. The research has demonstrated that phosphoric acid can be produced from several different Florida phosphate matrix samples. The principal benefits noted were high P_2O_5 recoveries and a sandy compact solid waste that will permit immediate land reclamation by backfilling mined-out land. Designs for a 100-pound-per-day pilot plant are being prepared.

The Tuscaloosa Metallurgy Research Laboratory, U.S. Bureau of Mines, Tuscaloosa, Ala., has, during 1973, continued the program sponsored by the U.S. Bureau of Mines and The Florida Phosphate Council to develop processes to effect rapid dewatering of phosphate slimes. Programs to characterize Florida phosphate slimes, to study electrophoretic mobilities and ion exchange properties, to develop tests to predetermine the settling rates of slimes, to study the flocculation and agglomeration responses of slimes, to evaluate the settling and dewatering characteristics of sand-slime mixtures, and to study the gelation tendencies of phosphate slimes will continue through 1974.

Platinum-Group Metals

By W. C. Butterman [1]

World production of the platinum-group metals continued its upward trend in 1973, increasing 21% over production in 1972. Republic of South Africa producers, in possession of long-term contracts with United States and Japanese automobile manufacturers, provided most of the increase. Demand, especially from United States and Japanese consumers, remained strong in 1973, and although supplies of most of the metals were adequate, prices rose significantly, partly because of inflationary pressures, devaluation of the U.S. dollar, and the very strong advance in the price of gold. The dealers' prices for rhodium and iridium, which became scarce during the year, increased sharply.

In the United States, significant excesses of platinum, palladium, and iridium were created in Government inventories when stockpile objectives were cut sharply in April; however, none of this metal became available to consumers during the year. Refinery production of primary platinum-group metals rose 29% in 1973, and production of secondary metals rose 4%. Imports were up 27%, and exports increased 16%. Sales to industry were 17% higher than in 1972, and industry stocks increased 11%.

Legislation and Government Programs.—In April the Office of Preparedness set new, sharply reduced, stockpile objectives. As a result, about 265,000 troy ounces of platinum, 926,000 troy ounces of palladium, and 15,000 troy ounces of iridium in inventory became excess to requirements. By yearend, however, congressional authorization for disposal of the excess metal had not been forthcoming. Thus, inventories of the three metals remained unchanged in 1973, except for the disposal of 174 ounces of nonstockpile-grade iridium.

On April 12, the Environmental Protection Agency (EPA) delayed application of the 1975 automobile emission standards for 1 year; instead for 1975, EPA set somewhat relaxed interim standards for California and even less stringent standards for the rest of the Nation. At midyear, EPA, having concluded that the danger from nitrogen oxide emissions had been overstated at the time the Clean Air Act of 1970 was written, recommended to Congress that the law be liberalized with respect to these emissions.

[1] Physical scientist, Division of Nonferrous Metals—Mineral Supply.

Table 1.—Salient platinum-group metals statistics

(Troy ounces)

	1969	1970	1971	1972	1973
United States:					
Mine production [1]	21,586	17,316	18,029	17,112	19,980
Value	$2,094,607	$1,429,521	$1,359,675	$1,267,298	$2,103,704
Refinery production:					
New metal	17,875	19,822	21,184	15,380	19,916
Secondary metal	371,659	350,176	278,175	255,641	265,901
Exports (except manufactures)	501,064	413,766	404,610	r 538,994	627,526
Imports for consumption	1,225,851	1,410,786	1,302,740	1,836,349	2,340,491
Stocks Dec. 31: Refiner, importer, dealer	r 1,068,108	r 710,024	r 796,791	r 930,853	1,033,124
Consumption	r 1,361,180	r 1,331,152	r 1,261,312	r 1,562,245	1,831,294
World: Production	3,431,155	4,238,956	4,084,110	r 4,268,590	5,173,558

r Revised.
[1] From crude platinum placers and byproduct platinum-group metals recovered largely from domestic copper ores.

Table 2.—Government inventory of platinum-group metals, December 31, 1973

(Troy ounces)

	Iridium	Palladium	Platinum
National stockpile	[1] 17,002	[2] 507,314	[3] 402,646
Supplemental stockpile	--	747,680	49,999
Total	17,002	1,254,994	452,645
Objective	1,800	328,500	187,500

[1] Includes 12 troy ounces nonstockpile-grade material.
[2] Includes 2,204 troy ounces nonstockpile-grade material.
[3] Includes 2,566 troy ounces nonstockpile-grade material.

DOMESTIC PRODUCTION

Domestic mine production of platinum-group metals increased 17% in quantity and 66% in value in 1973. Most of the palladium was recovered as a byproduct of copper refining, and most of the platinum and other metals of the group came from one placer deposit. This deposit, at Goodnews Bay, on the southwest coast of Alaska, is the only deposit in the United States mined primarily for platinum metals.

Refinery production of primary platinum-group metals rose 29% in 1973. Total secondary production rose 4%, owing mainly to a 25% rise in secondary platinum produced. Toll refining increased 4%. Scrap material accounted for 89% of the total material toll-refined; the balance consisted of crude platinum, nickel-copper sulfide matte, and anode slimes derived from the electrolytic refining of sulfide matte. These materials came from Colombia, Canada, Norway, and the Republic of South Africa.

Table 3.—New platinum-group metals recovered by refiners in the United States, by source [1]

(Troy ounces)

Year and source	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1969	8,702	8,387	570	135	70	11	17,875
1970	8,036	10,322	1,261	129	64	10	19,822
1971	10,198	10,237	498	154	83	14	21,184
1972	3,708	10,836	594	173	62	7	15,380
1973	5,560	13,121	957	176	88	14	19,916

[1] Excludes toll-refined metals; includes palladium refined from foreign crude platinum; 1969—163 ounces; 1970—24 ounces; 1971–73—none.

Table 4.—Secondary platinum-group metals recovered in the United States [1]

(Troy ounces)

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1969	126,822	227,763	2,250	208	11,743	2,873	371,659
1970	118,298	208,555	1,927	121	13,394	7,881	350,176
1971	103,429	161,099	2,186	352	8,837	2,272	278,175
1972	75,942	162,718	4,393	149	11,390	1,049	255,641
1973	94,884	150,019	6,785	20	11,561	2,632	265,901

[1] Excludes toll-refined metals.

Table 5.—Platinum-group metals toll-refined in the United States

(Troy ounces)

Year and source	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1969	1,209,202	945,106	9,186	2,197	73,139	8,609	2,247,439
1970	1,074,655	569,711	5,659	958	56,746	9,060	1,716,789
1971	777,562	593,842	12,063	4,169	51,291	9,225	1,448,152
1972	837,716	455,000	9,468	1,631	47,419	5,635	1,356,869
1973:							
From virgin material	32,883	115,766	1,158	102	10,542	1,239	161,690
From scrap material	754,407	462,381	5,833	13,546	35,035	11,068	1,246,270
Total	787,290	542,147	6,991	13,648	45,577	12,307	1,407,960

CONSUMPTION AND USES

Sales of the platinum-group metals to consuming industries rose 17% in 1973 to about 1.8 million troy ounces. Sales of four of the metals increased: Platinum 21%, palladium 16%, rhodium 55%, and ruthenium 4%. Sales of iridium and osmium declined 19% and 32%, respectively.

Platinum sales were 658,000 ounces, of which 36% went to the chemical industry, 19% to the petroleum refining industry, 18% to the electrical industry, and 11% to the glass/ceramics industry. The largest increases in sales went to the petroleum, glass, and electrical industries, with more modest gains in the chemical and jewelry industries and the miscellaneous uses category. Only the dental/medical industries used less platinum than in 1972.

Sales of palladium were just over 1 million ounces in 1973. Of this, 52% was used in the electrical industry, 26% in the chemical industry, and 13% in the dental and medical industry. The electrical industry alone consumed 99,000 ounces more in 1973 than in 1972. Dental and medical, jewelry, and miscellaneous uses each consumed substantially more than in 1972, but the chemical, petroleum, and glass industries consumed less than in 1972.

Iridium sales were 31,000 ounces, of which 35% went to the chemical industry, and 44% to the petroleum industry. Sales in each of the seven end-use categories were lower than in 1972.

Sales of osmium declined in 1973 to about 1,600 ounces all of which went to the chemical and dental and medical industries (62% and 38%, respectively).

Rhodium sales were nearly 72,000 ounces, of which 33% went to the chemical industry, 23% to the glass industry, 16% to the electrical industry, and 17% to the jewelry industry. Sales to all industries increased substantially compared with those in 1972.

Sales of ruthenium increased 4% to about 57,000 ounces. About 68% went to the chemical industry and 18% to the electrical industry.

The platinum-group metals are useful because of their extraordinary catalytic properties, resistance to chemical corrosion over a wide temperature range, and unique combination of physicochemical and electrical properties. The pattern of industrial applications in 1973 was similar to patterns in recent years. The patterns for the major metals, platinum and palladium, are shown in figure 1.

Early in the year, the Federal Bureau of Mines issued IC 8565, Demand for Platinum To Reduce Pollution From Automobile Exhausts, which dealt with platinum to be used for catalytic oxidation of hydrocarbons and carbon monoxide in automobile emissions.[2] This report estimated that about 1.4 million ounces of platinum would be needed to equip 1975 model automobiles sold in the United States. After EPA set relaxed interim standards, it became apparent that actual requirements would be lower. For a time after this decision, it was felt that a large percentage of 1975 cars would not need catalytic devices. By yearend, however, the major automobile manufacturers had determined that in order to meet even these relaxed standards, it would be necessary to equip most 1975 model cars with oxidative catalytic exhaust converters. Each

[2] Kusler, D. J. Demand for Platinum To Reduce Pollution From Automobile Exhausts. BuMines IC 8565, 1973, 32 pp.

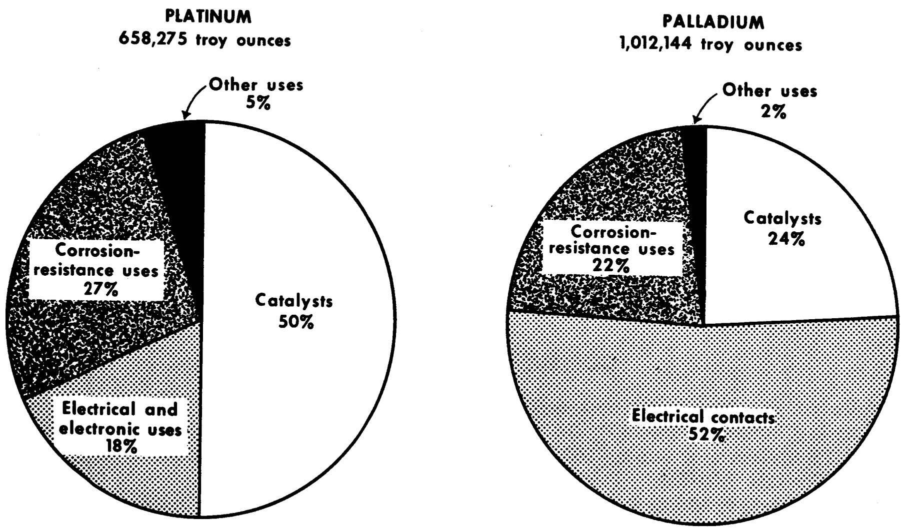

Figure 1.—Uses of platinum and palladium in 1973.

converter would contain, as the active material, between 0.05 and 0.10 troy ounce of a platinum-palladium mixture, the composition of which was expected to range in percent, from 70 platinum- 30 palladium to 80 platinum- 20 palladium.

In other areas of platinum-group metals usage, there were a number of developments in 1973. A special high-purity grade of platinum suitable for use in the production of optical glass fibers became available during the year. The maximum allowed content of metallic impurities in this grade is 10 parts per million.[3] The use of rhodium plated surfaces on electrical components, such as contacts, slip rings, and commutators increased.[4] Dispersion-strengthened platinum, platinum-rhodium, and iridium-rhodium, were developed for use in resistance thermometers, thermocouples, sensor shields, and jet thrusters used for spacecraft attitude control.[5] The use of platinum catalysts to reduce nitrogen oxides in the tail gas from nitric acid plants continued to grow.[6]

STOCKS

Stocks of platinum-group metals held by refiners, importers, and dealers increased 11% to just over 1 million troy ounces at yearend. Palladium stocks increased 22%, platinum stocks rose 5%, and rhodium stocks fell 10%. In addition to these stocks, there were Government stockpile inventories of platinum, palladium, and iridium, and stocks of platinum and palladium held by the New York Mercantile Exchange.

PRICES

Producers' prices for the platinum-group metals, which were under Government controls much of the year, increased 10% to 50% in February, underwent a short-lived 5% fluctuation in June, and then advanced again in late September (palladium, in mid-August) 5% to 14%. After price controls were removed from most nonferrous metals in December, rhodium and iridium prices increased another 14% to 15%. Ruthenium remained unchanged after the February increase to $60 per troy ounce, and osmium stayed at $200 per ounce throughout the year.

The dealers' price for iridium jumped from $250 to $450 per troy ounce in July because that metal became scarce, and ended the year at $525 per troy ounce. The

[3] Heywood, A. E. Production of Optical Glass Fibres. Platinum Metal Rev., v. 17, No. 3, July 1973, pp. 88–89.

[4] Materials Engineering. Chemically Inert Precious Metals Good for Tough Thermal Uses. V. 78, No. 5, October 1973, pp. 22–25.

[5] American Metal Market. Develop High Heat Material for Spacecraft Jet Thrusters. V. 80, No. 53, Mar. 16, 1973, p. 9.

[6] Searles, R. A. Pollution From Nitric Acid Plants. Platinum Metal Rev., v. 17, No. 2, April 1973, pp. 57–63.

dealers' price for rhodium advanced sharply in September, from $225 to $375 per troy ounce, and ended the year at $425 per troy ounce. Average prices for the year, calculated using the low ends of the ranges of weekly averages published by Metals Week, follow:

	Producer (per troy ounce)	Dealer (per troy ounce)
Platinum	$150.04	$154.85
Palladium	77.68	75.45
Rhodium	222.21	268.11
Iridium	223.07	357.78
Osmium	200.00	144.23
Ruthenium	58.85	114.90

Table 6.—Platinum-group metals sold to consuming industries in the United States

(Troy ounces)

Year and industry	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1969	r 519,414	758,738	14,218	1,472	50,144	17,194	r 1,361,180
1970	r 509,011	739,343	10,905	1,707	48,897	21,289	r 1,331,152
1971	r 426,684	760,106	15,512	2,126	34,366	22,518	r 1,261,312
1972:							
Chemical	225,895	292,710	12,429	1,997	15,358	40,984	589,373
Petroleum	r 98,847	14,499	16,725	--	149	--	r 130,220
Glass	26,970	2,250	58	--	13,923	--	43,201
Electrical	92,381	425,081	4,042	--	7,867	6,542	535,913
Dental and medical	30,462	94,274	376	374	48	441	125,975
Jewelry and decorative	20,655	19,375	1,565	(1)	6,593	1,810	r 49,998
Miscellaneous	50,089	27,835	2,559	r 26	2,157	4,899	r 87,565
Total	r 545,299	876,024	37,754	2,397	46,095	54,676	r 1,562,245
1973:							
Chemical	238,974	259,959	10,635	1,003	23,772	38,713	573,056
Petroleum	123,649	3,761	13,385	--	3,057	92	143,944
Glass	72,543	1,439	51	--	16,689	82	90,804
Electrical	117,094	523,716	3,516	--	11,387	10,332	666,045
Dental and medical	27,887	135,060	145	626	297	164	164,179
Jewelry and decorative	22,433	23,052	1,191	--	12,326	2,317	61,319
Miscellaneous	55,695	65,157	1,753	--	3,987	5,355	131,947
Total	658,275	1,012,144	30,676	1,629	71,515	57,055	1,831,294

r Revised.
[1] Revised to none.

Table 7.—Refiner, importer, and dealer stocks of platinum-group metals in the United States, December 31

(Troy ounces)

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1969	r 361,305	608,716	14,505	2,873	55,833	24,876	r 1,068,108
1970	r 291,544	332,726	13,366	1,868	47,767	22,753	r 710,024
1971	r 385,828	316,126	16,434	604	51,529	26,270	r 796,791
1972	r 426,611	405,793	14,987	82	56,967	26,413	r 930,853
1973 [1]	446,522	493,078	14,813	327	51,504	26,880	1,033,124

r Revised.
[1] Stocks of platinum and palladium in the Mercantile Exchange depositories as of December 28, 1973, were 115,200 troy ounces, and palladium 11,500 troy ounces.

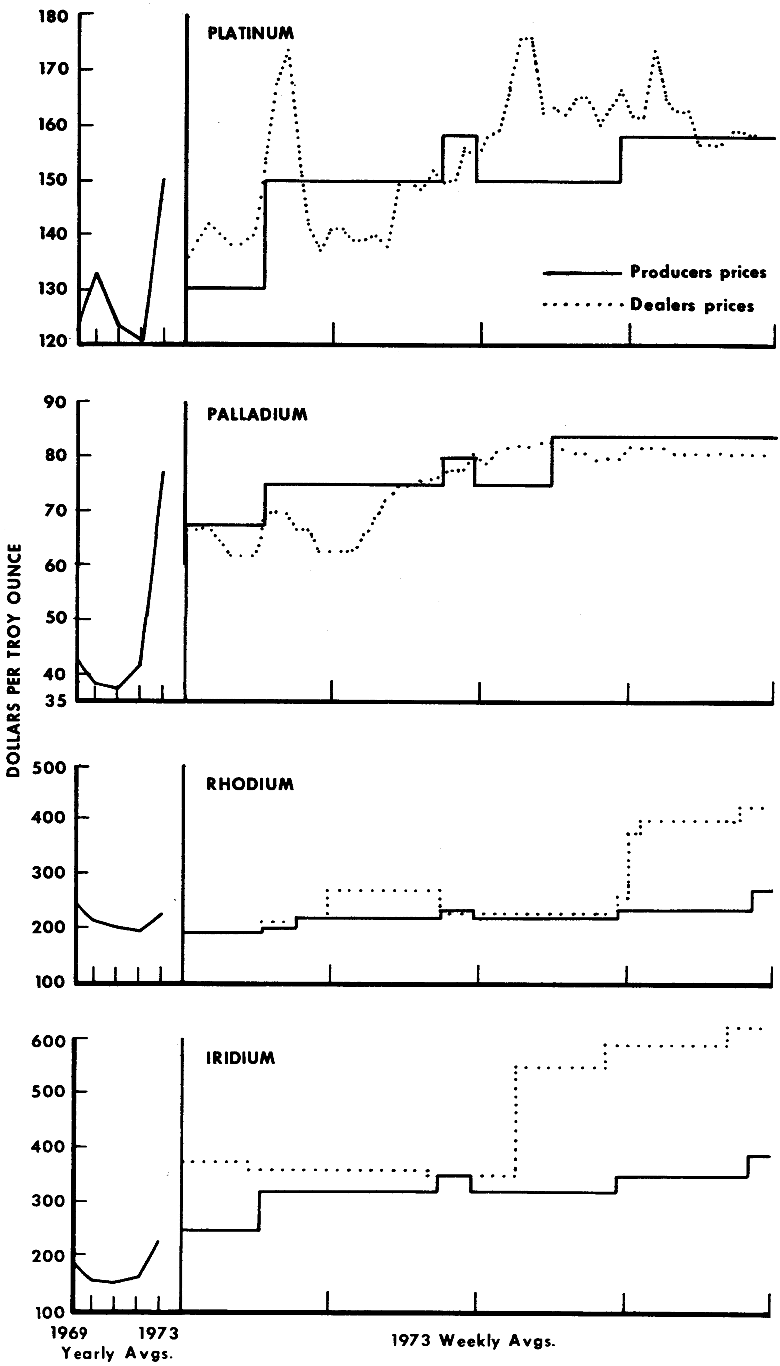

Figure 2.—Prices of four platinum-group metals.

FOREIGN TRADE

Exports of platinum-group metals in 1973 amounted to 628,000 ounces, of which about 439,000 ounces, or 70%, was platinum. Exports of platinum alone increased only 5%, whereas exports of the other metals of the group increased 54%; the increase in total group exports was 16%. As a result of rising prices, value of exports rose 50%, to nearly $78 million. Nearly 80% of the quantity exported went to just three countries: Japan (50%), West Germany (17%), and Belgium-Luxembourg (11%). Seventy-nine percent of the quantity exported to Japan, and 60% of the exports to West Germany, consisted of platinum.

Imports of the platinum-group metals increased 27% in 1973 to 2.3 million ounces valued at $249 million. Platinum comprised 32% of the imports, and palladium 49%. The amounts of platinum, palladium, and rhodium imported were higher than in 1972 by 10%, 28%, and 83%, respectively. The chief sources of platinum-group imports and of the three major metals of the group are shown in table 11.

Table 8.—U.S. imports for consumption of platinum-group metals

Year	Quantity (troy ounces)	Value (thousands)
1971	1,302,740	$93,674
1972	1,836,349	144,092
1973	2,340,491	248,832

Table 9.—U.S. exports of platinum-group metals, by country

Year and destination	Platinum and platinum-group ores and concentrates		Platinum and platinum-group metals, waste and scrap and sweepings		Platinum, unworked or partly worked, not rolled		Platinum, unworked or partly worked, rolled		Platinum-group metals unworked or partly worked, not rolled		Platinum-group metals unworked or partly worked, rolled	
	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)
1972:												
Argentina	--	--	--	--	--	--	--	--	126	$19	--	--
Australia	--	--	--	--	630	$74	--	--	r 2,320	r 130	40	$2
Belgium-Luxembourg	2,100	$77	41,133	$1,936	324	52	--	--	1,560	101	--	--
Brazil	66	13	--	--	4,496	23	--	--	634	29	93	7
Canada	--	--	3,100	50	1,212	178	272	$57	4,541	199	944	48
France	--	--	--	--	2,101	243	108	1	2,004	152	173	9
Germany, West	28,451	313	29,635	1,513	37,294	5,215	2,100	256	22,614	1,642	591	53
Hong Kong	--	--	--	--	33	6	1,003	107	176	5	23	1
Italy	--	--	--	--	56	8	--	--	17,270	636	1,895	37
Japan	--	--	--	--	195,159	26,928	12,772	1,662	42,757	3,025	3,772	190
Mexico	--	--	--	--	752	168	17	3	2,156	100	42	5
Netherlands	--	--	--	--	1,950	294	--	--	7,665	677	100	2
South Africa, Republic of	--	--	1,093	111	13	3	--	--	--	--	--	--
Switzerland	16	8	--	--	4,456	616	--	--	492	51	--	--
United Kingdom	1,049	71	27,042	2,190	18,461	2,058	3	1	3,627	178	1,923	52
Other	--	--	--	--	138	22	2	1	4,337	162	82	6
Total	31,682	482	102,003	5,800	267,075	35,888	16,277	2,088	r 112,279	r 7,106	9,678	412
1973:												
Australia	--	--	--	--	2,881	443	--	--	6,025	500	--	--
Belgium-Luxembourg	--	--	69,381	5,297	110	31	--	--	103	17	--	--
Brazil	360	14	--	--	4,342	595	--	--	711	37	644	53
Canada	--	--	125	6	1,698	342	538	108	16,867	1,015	1,130	51
China, People's Republic of	--	--	--	--	17,792	2,951	--	--	331	19	--	--
Colombia	--	--	--	--	14	3	21	4	1,151	106	--	--
France	118	5	--	--	3,771	564	7	1	1,363	83	338	11
Germany, West	2,996	267	15,416	1,127	43,833	7,048	17	3	38,373	3,055	3,245	288
Hong Kong	--	--	--	--	10	2	696	111	--	--	185	11
India	--	--	--	--	--	--	--	--	1,290	79	20	1
Israel	--	--	--	--	--	--	--	--	304	12	3,674	111
Italy	--	--	--	--	2	(1)	--	--	2,893	236	--	--
Japan	--	--	323	52	218,895	34,170	25,336	3,954	50,900	5,721	15,486	1,346
Korea, Republic of	--	--	--	--	72	13	--	--	911	72	--	--
Mexico	--	--	--	--	200	41	46	9	5,034	367	47	3
Netherlands	--	--	50	19	5,967	936	--	--	10,495	1,452	3,157	227
South Africa, Republic of	--	--	2,227	72	4	1	37	7	--	--	--	--
Spain	821	204	--	--	--	--	--	--	1,125	87	--	--
Switzerland	87	29	32	9	1,355	193	216	70	2,416	162	3,713	295
United Kingdom	455	65	18,469	2,487	326	67	4	1	8,613	428	34	2
Other	--	--	3	(1)	340	46	59	12	7,344	386	152	13
Total	4,837	584	106,026	9,069	301,612	47,446	26,977	4,280	156,249	13,834	31,825	2,412

r Revised.
[1] Less than ½ unit.

Table 10.—U.S. imports for consumption of platinum-group metals, by country

Year and country	Unwrought: Grains and nuggets (platinum) Quantity (troy ounces)	Grains and nuggets (platinum) Value (thousands)	Sponge (platinum) Quantity (troy ounces)	Sponge (platinum) Value (thousands)	Sweepings waste and scrap Quantity (troy ounces)	Sweepings waste and scrap Value (thousands)	Iridium Quantity (troy ounces)	Iridium Value (thousands)	Palladium Quantity (troy ounces)	Palladium Value (thousands)	Rhodium Quantity (troy ounces)	Rhodium Value (thousands)
1972	58,284	$7,254	350,143	$42,622	75,210	$7,600	24,827	$4,038	289,055	$12,929	47,378	$8,735
1973:												
Australia	--	--	--	--	4,904	623	--	--	--	--	--	--
Belgium-Luxembourg	--	--	--	--	21,807	3,313	--	--	--	--	--	--
Brazil	--	--	--	--	2,706	433	--	--	--	--	--	--
Canada	4	(1)	--	--	19,465	2,378	25	6	3,503	267	--	--
Chile	--	--	--	--	1,761	211	--	--	--	--	--	--
Colombia	16,642	2,048	3,254	380	3,714	630	--	--	--	--	--	--
Costa Rica	--	--	--	--	1,639	262	--	--	--	--	--	--
El Salvador	--	--	--	--	371	26	--	--	--	--	--	--
Finland	--	--	--	--	1,261	92	--	--	--	--	--	--
France	--	--	408	120	--	--	--	--	--	--	--	--
Germany, West	--	--	5,150	681	--	--	86	33	2,382	197	3	1
Ireland	--	--	--	--	23	3	--	--	--	--	--	--
Japan	--	--	24,952	3,597	35	4	--	--	1,600	132	--	--
Mexico	--	--	112	14	12,710	598	--	--	--	--	113	12
Netherlands	--	--	--	--	2,215	329	--	--	42,366	3,399	100	21
New Zealand	--	--	--	--	61	6	--	--	--	--	--	--
Norway	850	134	--	--	--	--	--	--	5,650	389	--	--
Panama	--	--	--	--	168	8	--	--	--	--	--	--
South Africa, Republic of	400	60	88,794	13,166	5,977	727	1,860	544	135,365	9,607	2,045	408
Sweden	--	--	--	--	4,253	391	--	--	--	--	--	--
Switzerland	292	44	--	--	--	--	--	--	11,424	752	--	--
U.S.S.R	490	75	2,486	416	--	--	--	--	54,275	3,732	14,151	3,048
United Kingdom	468	35	374,115	54,734	917	130	17,730	4,233	239,500	18,138	56,444	12,097
Uruguay	--	--	--	--	500	60	--	--	--	--	--	--
Venezuela	--	--	--	--	47	5	--	--	--	--	--	--
Total	19,146	2,396	499,271	73,108	84,534	10,229	19,701	4,816	496,065	36,613	72,856	15,587

See footnotes at end of table.

Table 10.—U.S. imports for consumption of platinum-group metals, by country—Continued

Year and country	Unwrought				Semimanufactured								Total	
	Ruthenium		Other platinum-group metals		Platinum		Palladium		Rhodium		Other platinum-group metals			
	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)	Quantity (troy ounces)	Value (thousands)
1972	61,191	$2,602	103,419	$12,134	207,960	$22,869	613,174	$22,488	3,426	$543	2,282	$278	1,836,349	$144,092
1973:														
Australia	--	--	--	--	--	--	--	--	--	--	--	--	4,904	623
Belgium-Luxembourg	--	--	--	--	--	--	--	--	--	--	--	--	21,807	3,313
Brazil	--	--	--	--	--	--	--	--	--	--	--	--	2,706	433
Canada	8,200	349	221	19	274	42	1,589	71	--	--	--	--	33,281	3,132
Chile	--	--	--	--	--	--	--	--	--	--	--	--	1,761	211
Colombia	--	--	--	--	3,600	472	--	--	--	--	--	--	27,210	3,530
Costa Rica	--	--	--	--	--	--	--	--	--	--	--	--	1,639	262
El Salvador	--	--	--	--	--	--	--	--	--	--	--	--	371	26
Finland	--	--	--	--	--	--	--	--	--	--	--	--	1,261	92
France	--	--	--	--	545	72	--	--	--	--	--	--	953	192
Germany, West	--	--	--	--	--	--	3,336	235	--	--	--	--	10,957	1,147
Ireland	--	--	--	--	--	--	--	--	--	--	--	--	23	3
Japan	--	--	109,231	16,564	24,754	3,533	3,896	295	--	--	--	--	164,468	24,125
Mexico	--	--	--	--	--	--	--	--	--	--	--	--	12,935	624
Netherlands	--	--	4,501	449	305	40	--	--	162	34	--	--	49,649	4,272
New Zealand	--	--	--	--	--	--	--	--	--	--	--	--	61	6
Norway	1,525	70	22,578	701	6,384	686	1,300	79	--	--	--	--	38,287	2,059
Panama	--	--	--	--	--	--	--	--	--	--	--	--	168	8
South Africa, Republic of	4,282	227	4,338	424	100	13	2,250	176	--	--	--	--	245,411	25,352
Sweden	--	--	--	--	--	--	--	--	--	--	--	--	4,253	391
Switzerland	--	--	1,620	360	10,787	1,677	5,026	377	--	--	--	--	29,149	3,210
U.S.S.R	--	--	92,429	14,077	83,781	12,698	614,462	40,183	20,193	1,727	--	--	882,267	75,956
United Kingdom	53,211	2,729	8,666	1,283	25,185	3,716	26,381	2,084	--	--	3,806	621	806,423	99,800
Uruguay	--	--	--	--	--	--	--	--	--	--	--	--	500	60
Venezuela	--	--	--	--	--	--	--	--	--	--	--	--	47	5
Total	67,218	3,375	243,584	33,877	155,715	22,949	658,240	43,500	20,355	1,761	3,806	621	2,340,491	248,832

[1] Less than ½ unit.

Note: In addition, platinum content from materials n.e.s.: 1972, 45,229 troy ounces ($3,222,233); and platinum content from precious metal ores, 10,606 troy ounces ($952,980); 1973, platinum content from materials n.e.s.: 12,488 troy ounces ($1,190,125); and platinum content from precious metal ores, 149,654 troy ounces ($19,477,220).

WORLD REVIEW

World production of the platinum-group metals increased 21% in 1973 to 5.2 million troy ounces, as demand increased, especially in the United States and Japan. Most of the increment came from Republic of South Africa producers, who were gearing up for anticipated high demand in the United States for platinum and palladium in automobile emissions control catalysts, beginning in 1974. As in the past, virtually all (99%) of the platinum-group metals were mined in just three countries, the U.S.S.R., the Republic of South Africa, and Canada.

In the United States, which imports about 99% of its requirements for primary platinum-group metals, mine production rose 17% to 19,980 troy ounces. Platinum metals were produced in Japan as byproducts of copper refining, and small amounts of platinoid concentrates were produced in the Philippines as byproducts of nickel-cobalt mining. Placer mining continued in Colombia at the same pace that it has for many years, yielding about 26,000 ounces of platinoids, which were refined in the United States.

Canada.—Canadian production of platinum-group concentrates and refined metals fell 29% in 1973, to 288,000 troy ounces in spite of a 4% rise in nickel production. In Canada, the platinum-group metals are produced as byproducts of nickel-copper mining by two companies, The International Nickel Co. Ltd. (INCO), and Falconbridge Nickel Mines, Ltd. The mines are in Sudbury, Ontario, and Thompson, Manitoba. INCO's platinoid-bearing concentrates are refined to metal in the United

Table 11.—Imports of platinum-group metals, by source

(Percent of total imports)

Source	Platinum-group	Platinum	Palladium	Rhodium
U.S.S.R	38	11	58	37
United Kingdom	34	53	23	61
Republic of South Africa	10	13	12	2
Japan	7	7	(1)	(1)
Other	11	16	7	(2)
Total	100	100	100	100

[1] Included with "Other."
[2] Less than ½ unit.

Table 12.—Platinum-group metals: World production, by country[1]

(Troy ounces)

Country	1971	1972	1973 p
Australia:			
Palladium, metal content, from nickel ore	--	--	e 1,500
Platinum, metal content, from nickel ore	--	--	e 450
Canada: Platinum and other platinum-group metals	475,169	406,048	288,000
Colombia: Placer platinum	25,610	24,111	26,358
Ethiopia: Placer platinum	217	248	235
Finland: Platinum-group metals recovered from domestic copper ores by copper refinery e	600	650	725
Japan:			
Palladium from refineries	5,375	5,659	10,014
Platinum from refineries	3,451	4,240	6,827
Philippines:			
Palladium metal	1,756	4,810	4,205
Platinum metal	703	2,712	2,464
South Africa, Republic of:			
Platinum-group metals from platinum ores e	1,250,000	r 1,450,000	2,360,000
Osmiridium from gold ores (sales) e	3,200	3,000	2,800
U.S.S.R.: Placer platinum and platinum-group metals recovered from platinum-nickel-copper ores e	2,300,000	2,350,000	2,450,000
United States: Crude placer platinum and byproduct metals recovered largely from domestic gold and copper refining	18,029	17,112	19,980
Total	4,084,110	r 4,268,590	5,173,558

e Estimate. p Preliminary. r Revised.
[1] Excludes refined platinum production from Norway, which is derived from imported raw materials, chiefly (if not wholly) of Canadian origin, in order to avoid double counting.

Kingdom, whereas Falconbridge's concentrates are refined in the United States after intermediate processing in Norway.

South Africa, Republic of.—South Africa was the world's largest producer of platinum (1.5 million ounces), and the second largest producer, after the U.S.S.R., of the total platinum-group metals (2.4 million ounces) in 1973. The platinum-group metals were the principal products at five operating mines, all of which were on the Merensky Reef member of the Bushveld Igneous Complex. The Reef, which is in the Transvaal, is a remarkably uniform and extensive orebody in which recoverable values are about 0.2 troy ounce of platinoids per ton of ore. The metals are present in the proportions of platinum 62%, palladium 25%, and the other four metals 13%. (Much of the data available from the Republic of South Africa are in terms of platinum alone. Such data have been converted to platinum-group metals data in this report by applying the 62% factor to all mines.) In addition, a small amount of osmiridium was produced as a byproduct of gold mining. South African reserves of platinum-group metals were estimated at greater than 325 million troy ounces,[7] and resources at between 650 and 1,220 million troy ounces.[8]

Rustenburg Platinum Mines, Ltd., the oldest and largest producer, continued its expansion program, aimed at a capacity of 2.5 million ounces by 1976. By yearend 1973, its production rate was estimated to have reached about 1.6 million troy ounces of platinum-group metals per year. Rustenburg's 3-year contract with Ford Motor Co. for 500,000 ounces of platinum per year, was stretched to 5 years, covering 1975 to 1979, and palladium was substituted for one-fourth of the platinum. Development of the Amandelbult mine continued some 20 miles northeast of the Union mine; it was expected to be operational in 1976. Work also continued on a fivefold expansion of the refinery at Wadeville (jointly owned with Johnson, Matthey & Co.). In the past, virtually all of the refining of Rustenburg concentrates and mattes has been done by Johnson, Matthey & Co. in the United Kingdom.

After signing a 10-year contract with General Motors Corp. in late 1972 to supply 300,000 ounces of platinum and 120,000 ounces of palladium per year, Impala Platinum, Ltd., the second largest producer, announced early in 1973 its intention of expanding production from 560,000 ounces of metals per year to 1.2 million ounces, and later in the year increased the target to 1.5 million ounces to be available by the end of 1974. Impala is a vertically integrated company with its own refinery at Springs, near Johannesburg, and with its own sales organization.

Western Platinum Ltd. completed its second full year of operation, producing on the order of 80,000 ounces of platinum-group metals. Concentrates were smelted to a copper-nickel matte, which was sent to Falconbridge Nickel Mines' electrolytic refinery in Kristiansand, Norway, for processing. The anode slimes from Norway were sent to PGP Industries in California for final refining and distribution. Lonrho, Ltd. (which with Falconbridge and Superior Oil Co., owns Western Platinum), was building a refinery of 150,000-ounce capacity at Brakpan, Transvaal, intended to toll-refine Western's output starting in April 1974.

Atok Platinum Mines, Pty., Ltd., continued its comparatively small-scale operation, producing about 18,000 ounces of platinum-group metals. Concentrates were smelted to matte at Western's smelter and sent to Falconbridge's refinery in Norway. Expansion of capacity to 40,000 ounces of platinum-group metals per year was in progress.

U.S.S.R.—The U.S.S.R. was the world's largest producer of the platinum-group metals in 1973. Nearly 2.5 million troy ounces was mined from placer deposits in the central Urals, and from lode deposits (as a byproduct of nickel and copper mining) in the Norilsk-Talnakh area, of northwestern Siberia, and in the Petsamo district of the Kola Peninsula. Production from placer deposits has been declining for decades, and probably contributed no more than 10% of the national production in 1973. Platinum and palladium comprised about 90% of the output of the refined metals, and the platinum/palladium ratio was estimated to lie between 2 and 3.5 to 1. Expansion of the mining-smelting com-

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[7] Watson, D. A. B. A New Mining Area for Rustenburg. Platinum Metals Rev., v. 15, No. 1, January 1971, pp. 26–28.

[8] Clark, A. L., N. J. Page, G. A. Desborough, and R. L. Parker. Platinum-Group Metals, Chapter in United States Mineral Resources. U.S. Geol. Survey Prof. Paper 820, pp. 537–545.

Newman, S. C. Platinum. S. Africa Inst. of Min. and Met. Trans., 1973, pp. A52–A68.

plex near Talnakh continued in 1973. The Oktyabr'skiy mine was being readied for production in 1974, and development of the Taimyr mine was begun.[9] Work continued on what was reported to be the world's largest nickel smelter.[10] These developments imply a major expansion in platinum-group metals production by the end of the decade.

TECHNOLOGY

In February the National Academy of Sciences issued a report on its study, undertaken at the behest of Congress, on the technological feasibility of meeting the motor vehicle emissions requirements of the Clean Air Act of 1970. The report indicated that the requirements could be met, at least for the 1975 model year, but expressed reservations about catalyst-equipped engines vis à vis other types, as the stratified charge engine, on the grounds of cost, fuel economy, maintainability, and durability.[11] However, the durability of automotive catalysts appeared to be sufficient to satisfy EPA requirements.[12] The National Materials Advisory Board reported on the search for substitutes for platinum in automobile emission control devices and in petroleum refining.[13] They concluded, with respect to automotive emissions that, ". . . at present, no base metal catalyst appears promising for use in the oxidizing reactor." They found also that, ". . . no complete substitutes for platinum in catalytic reforming are currently available and the likelihood of developing sufficiently active and selective catalysts to replace it in existing reforming reactors is extremely remote."

The Second International Symposium on Platinum Coordination Complexes in Cancer Chemotherapy was held in Oxford, England, in April. Clinical trials of the first described cancer inhibitory compound, cis-dichlorodiammine platinum II, were reviewed, and discussions were held on the chemistry and biological effects of platinum compounds.[14] The relationships between certain structural features of platinum complexes and antitumor activity were explored in a paper published earlier in the year.[15]

Interest in ruthenium-molybdenum and ruthenium-tungsten alloys, which in the early 1960's had been studied for possible use in nuclear reactors, was revived when it was found that the temperature coefficients of resistivity of thin films of the alloys could be varied from negative to positive by controlling the temperature of the substrate during deposition. This property suggested use as temperature-compensating components of integrated circuits. The hardness, high melting points, and good resistance to corrosion of these alloys suggested possible uses in electrical contacts operating under severe conditions.

A new family of platinum alloys containing rhodium, tungsten, hafnium, and titanium was developed for the encapsulation of plutonium oxide heat sources used in the thermoelectric power generators of space vehicles.[16]

Considerable experimental work continued on the development of dispersion strengthened (DS) platinum and platinum alloys. The disperse phase, usually with thoria or alumina present in amounts of about 0.5 to 2 volume-percent, hardens the metal and stabilizes its grain structure. The DS metals exhibit superior strength and durability under stress at high temperatures, but at the same time, retain, nearly unchanged, the room-temperature mechanical working properties and electrical properties of the pure metal or alloy. Some possible applications are high-temperature thermocouples and other temperature sensors, spark plugs, high-temperature conductors, and equipment for containing and handling molten glass.[17]

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[9] Shabad, T. Soviet Starts Work in Arctic Mine To Produce Platinum-Group Metals. New York Times, v. 123, No. 42,450, Apr. 15, 1974. p. 47.

[10] Metals Sourcebook. V. 1, No. 22, Nov. 19, 1973, p. 2.

[11] National Academy of Sciences. Report by the Committee on Motor Vehicle Emissions. Feb. 12, 1973, 139 pp.

[12] Aykan, K., W. A. Manion, J. M. Mooney and R. D. Hoyer. Durability of Monolithic Auto Exhaust Oxidation Catalysts in the Absence of Poisons. SAE, Paper 730592, 1973, 8 pp.

[13] National Materials Advisory Board. Substitute Catalysts for Platinum in Automobile Emission Control Devices and Petroleum Refining. NMAB 297, 1973, 94 pp.

[14] Connors, T. A. Platinum Coordination Complexes in Cancer Chemotherapy. Platinum Metal Rev., v. 17, No. 1, April 1973, pp. 2–13.

[15] Cleare, M. J., and J. D. Hoeschele. Anti-Tumor Platinum Compounds. Platinum Metal Rev., v. 17, No. 1, April 1973, pp. 2–13.

[16] Materials Engineering. Chemically Inert Precious Metals Good for Tough Thermal Uses. V. 78, No. 5, October 1973, pp. 22–25.

[17] Work cited in footnote 16.

Potash

By William F. Keyes [1]

After a moderate increase in 1972, domestic production of potash declined in 1973. A strong demand during most of the year, particularly in the last 6 months, resulted in a 755,000 ton increase in apparent consumption of K_2O. Exports rose moderately. There was a strong increase in imports, and producers' stocks declined to less than half the level of the previous year. The portion of domestic apparent consumption supplied by imports continued to mount and in 1973 equaled 65%. One mine in the United States ceased operations at midyear, and other mines reported production gains, some of them significantly greater than those in 1972. As the year ended, prorationing and pricing regulations in the Province of Saskatchewan, Canada, were overtaken by a rising demand for potash, and quotas were increased significantly. However, transportation presented a problem, and at yearend, potash was in short or tight supply in many areas of the United States.

Table 1.—Salient statistics on potassium salts

(Thousand short tons and thousand dollars)

Item	1969	1970	1971	1972	1973
United States					
Production	4,918	4,853	4,543	4,738	4,684
Approximate K_2O equivalent	2,804	2,729	2,587	2,659	2,603
Value	73,572	98,123	100,527	106,680	112,613
Sales by producers	5,340	4,703	4,578	4,653	5,174
Approximate K_2O equivalent	3,069	2,669	2,592	2,618	2,865
Value at plant	78,062	92,373	102,099	104,680	123,738
Average value per ton	14.62	19.64	22.30	22.50	23.92
Exports [1]	1,233	966	1,033	1,353	1,579
Approximate K_2O equivalent	700	544	564	764	889
Value	33,061	28,473	35,323	45,858	57,997
Imports for consumption [1]	3,926	4,403	4,672	4,979	6,064
Approximate K_2O equivalent	2,332	2,605	2,766	2,961	3,594
Value	60,703	94,734	111,844	119,666	146,436
Apparent consumption [2]	8,033	8,140	8,217	8,279	9,659
Approximate K_2O equivalent	4,701	4,730	4,794	4,815	5,570
World Production, Marketable:					
Approximate K_2O equivalent	19,198	20,013	21,945	22,497	24,212

[1] Excludes potassium chemicals and mixed fertilizers.
[2] Measured by sales plus imports minus exports.

DOMESTIC PRODUCTION

Domestic production of marketable potassium salts decreased 2.1% in 1973, compared with that in 1972, in terms of K_2O equivalent. Nevertheless, the value of production increased to a total of $112.6 million. Table 2 provides details of production and sales by product.

During 1973, one company, Teledyne Potash (formerly U.S. Potash and Chemical Co.), ceased operations. Six producers were, therefore, left in operation in New Mexico: AMAX Chemical Corp., Duval Corp., International Minerals & Chemical Corp., Kerr-McGee Corp., National Potash Co., and Potash Co. of America, a division of Ideal Basic Industries, Inc. In Utah three compa-

[1] Physical scientist, Division of Nonmetallic Minerals—Mineral Supply.

nies produced potash: Texas Gulf Inc., which produced potash by solution mining a bedded deposit; Great Salt Lake Minerals and Chemicals Corp., which treated brines from the Great Salt Lake; and Kaiser Aluminum & Chemical Corp., which treated natural brines near Wendover.

Searles Lakes Chemical Corp., a subsidiary of Occidental Petroleum Corp., continued to develop plans for producing potash and other minerals from Searles Lake brines at Trona, Calif. The mining plan was awaiting approval by the U.S. Geological Survey which is required for operations on U.S. Government lands. Output of 100,000 short tons of sodium borate, 150,000 short tons of sodium carbonate, and 115,000 short tons of potassium sulfate annually is envisioned.

Eighty-three percent of the domestic potash was produced in New Mexico. New Mexico's share declined 3% because of the closing of Teledyne Potash and because of production increases in Utah and California. The average K_2O content of crude salts produced at New Mexico mines declined again, to 16.1%. Total plant capacity of potash producers in the United States was about 3.5 million tons of K_2O equivalent prior to the closing of the Teledyne mine.

In 1973 imports of potash were equal to 65% of domestic consumption. This percentage had been increasing for a decade and, given the existence of the huge Canadian industry, it appeared that the trend would not be reversed. These increasing imports, coupled with the lower grade of domestic ore now being mined and the closing of one mine, all indicate continuing relative decline in the domestic potash-producing industry unless potash prices rise more rapidly than the general price level.

Table 2.—Marketable potassium salts produced and sold or used in the United States, in 1973, by product

(Thousand short tons and thousand dollars)

Item	Production			Sold or used		
	Gross weight	K_2O equivalent	Value [1]	Gross weight	K_2O equivalent	Value
January–June 1973:						
Muriate of potash, 60% K_2O minimum:						
Standard	927	565	18,935	1,059	645	21,490
Coarse	442	270	10,022	571	349	12,989
Granular	341	207	7,802	461	281	10,583
Potassium sulfate	228	118	9,636	270	139	11,372
Other potassium salts [2]	401	149	8,311	566	206	11,558
Total [3]	2,339	1,309	54,705	2,926	1,620	67,990
July–December 1973:						
Muriate of potash, 60% K_2O minimum:						
Standard	933	569	20,595	896	546	19,718
Coarse	394	241	9,439	375	230	8,967
Granular	384	233	9,364	385	234	9,405
Potassium sulfate	222	115	9,563	224	115	9,628
Other potassium salts [2]	411	135	8,947	369	120	8,029
Total [3]	2,345	1,294	57,908	2,248	1,245	55,747
Grand total [3]	4,684	2,603	112,613	5,174	2,865	123,738

[1] Derived from reported value of "Sold or used."
[2] Figures for chemical and soluble muriates and manure salts are included with potassium-magnesium sulfate.
[3] Data may not add to totals shown because of independent rounding.

Table 3.—Crude potassium salts produced, and marketable salts produced and sold or used in New Mexico

(Thousand short tons and thousand dollars)

Period	Crude salts[1]		Marketable potassium salts					
	Mine production		Production			Sold or used		
	Gross weight	K_2O equivalent	Gross weight	K_2O equivalent	Value[2]	Gross weight	K_2O equivalent	Value
1972:								
January–June	8,718	1,460	2,128	1,187	47,018	2,336	1,294	51,400
July–December	8,567	1,411	1,994	1,108	44,097	1,753	991	38,461
Total[3]	17,285	2,871	4,122	2,296	91,115	4,089	2,285	89,861
1973:								
January–June	8,671	1,411	1,998	1,112	45,075	2,498	1,372	56,291
July–December	8,421	1,335	1,940	1,055	46,920	1,916	1,049	46,747
Total[3]	17,092	2,746	3,938	2,168	91,996	4,414	2,422	103,038

[1] Sylvite and langbeinite.
[2] Derived from reported value of "Sold or used."
[3] Data may not add to totals shown because of independent rounding.

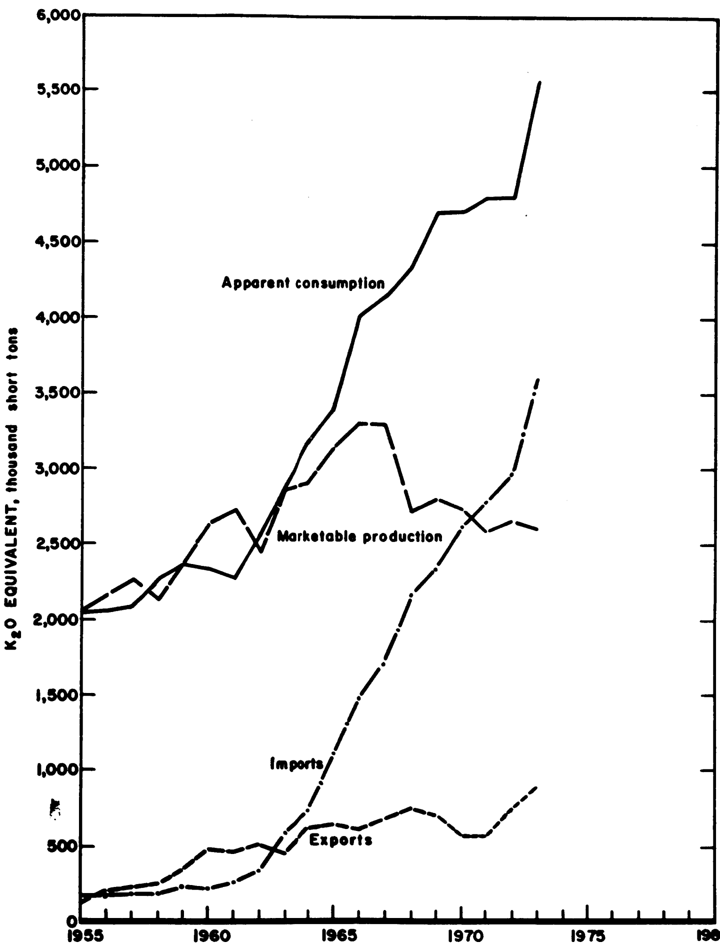

Figure 1.—Marketable production, apparent consumption, exports, and imports of potassium salts measured in K_2O equivalent.

CONSUMPTION AND USES

Apparent consumption of potash in the United States increased to 5.57 million short tons of K_2O in 1973, as measured by sales reported by domestic producers plus imports less exports; this was an increase of 16% over the 1972 level.

The Potash Institute of North America reported (table 4) U.S. sales of domestic and Canadian potash of 5.65 million short tons, in terms of K_2O equivalent, of which 307,000 tons, or 5.4%, was sold as chemical potash. In addition, offshore imports of fertilizer K_2O into the United States were reported as 87,573 tons of K_2O. Some 42% of agricultural potash was consumed in the north central States of Illinois, Indiana, Iowa, Ohio, and Minnesota.

Table 4.—Sales of potash salts in 1973, by State of destination

(Short tons K_2O equivalent)

Destination	Agricultural potash	Chemical potash	Destination	Agricultural potash	Chemical potash
Alabama	124,735	46,976	Nebraska	55,245	400
Arizona	982	88	Nevada	41	288
Arkansas	73,791	1,183	New Hampshire	457	--
California	68,181	6,365	New Jersey	17,430	1,863
Colorado	11,216	435	New Mexico	2,324	10
Connecticut	5,279	439	New York	69,442	90,083
Delaware	21,541	23,422	North Carolina	139,494	1,530
Florida	261,208	1,337	North Dakota	21,435	26
Georgia	281,749	3,558	Ohio	362,304	10,134
Hawaii	25,973	--	Oklahoma	29,061	501
Idaho	15,012	--	Oregon	19,150	1,187
Illinois	654,506	50,449	Pennsylvania	67,840	4,966
Indiana	461,192	7,767	Rhode Island	1,978	630
Iowa	405,689	864	South Carolina	101,684	989
Kansas	45,508	1,865	South Dakota	14,262	--
Kentucky	119,801	17,883	Tennessee	123,436	274
Louisiana	65,637	1,111	Texas	311,887	13,133
Maine	13,635	196	Utah	615	141
Maryland	57,948	1,532	Vermont	7,164	--
Massachusetts	4,749	890	Virginia	97,364	512
Michigan	146,086	1,153	Washington	32,574	3,275
Minnesota	347,830	444	West Virginia	4,130	811
Mississippi	163,660	1,762	Wisconsin	254,581	1,556
Missouri	225,954	4,585	Wyoming	2,375	699
Montana	5,597	137	Total	[1] 5,343,732	[2] 307,449

[1] Distribution of K_2O—1,377,983 tons as standard muriate, 1,960,166 tons as coarse muriate, 1,385,907 tons as granular muriate, 376,890 tons as soluble muriate, and 242,786 tons as sulfates.

[2] Distribution of K_2O—204,774 tons as muriate, 98,000 tons as soluble muriate, and 4,675 tons as sulfates.

Source: Potash Institute of North America, Atlanta, Ga.

STOCKS

Domestic yearend stocks of marketable potassium salts decreased 56% to 206,000 short tons. This was the lowest level of producers' stocks since the early 1950's when the industry was expanding to its present size.

Table 5.—Yearend stocks of marketable potassium salts in the United States

(Thousand short tons)

Year	Number of producers	Stocks, Dec. 31: Gross weight	Stocks, Dec. 31: K_2O equivalent
1969	12	723	392
1970	13	875	454
1971	11	796	428
1972	11	r 878	r 468
1973	11	388	206

r Revised.

PRICES

Bulk prices for potash remained relatively steady under Cost of Living Council guidelines until October 25, when fertilizer materials, including potash, were exempted from phase 4 controls. The Council explained its action by pointing out that fertilizer producers had insufficient cost justification to implement price increases under Economic Stabilization Program regulations, and consequently the gap between domestic and world prices was so large that needed domestic supplies were being shipped abroad. Potash prices rose thereafter but at a rate slower than that of other fertilizer materials and slower than raw materials in general.

The Saskatchewan Government continued to maintain a floor price of 33.75 cents per unit of K_2O for all sales of potash. As market demand increased, and as permitted production under the prorationing scheme was also increased, prices rose on the world market, and the floor price became inoperative.

Table 6.—Bulk prices for potash in 1973 [1]

(U.S. cents per unit K_2O)

	Jan. 1	Feb. 1	May 15	Aug. 1	Dec. 31
Muriate, 60% K_2O minimum:					
Standard	33.75	35	35	35	44
Soluble 62%/63% K_2O	36	39	39	37	47
Coarse	39	42	42	42	47
Granular	40	43	43	43	49
Sulfate of potash, 50% K_2O minimum:					
Regular	80	80	80	85	90
Granular	40	43	43	43	49
Mine run salts, minimum 20% K_2O	17.65	17.65	17.65	17.65	17.65

[1] Carlots, f.o.b. cars, Carlsbad, N. Mex.

Source: Potash Co. of America, Division of Ideal Basic Industries, Inc.

FOREIGN TRADE

Both exports and imports of potash materials increased considerably in 1973 compared with 1972. The relatively small exports and imports of potash materials for chemical purposes showed large percentage increases. Total exports in terms of K_2O content were up 16% and total imports rose 21%. Latin America as a whole took the largest share of U.S. exports. Canada, as usual, was the major supplier, contributing almost 96% of U.S. imports.

Table 7.—U.S. exports of potash materials, by use

Materials	Approximate equivalent as potash (K_2O), percent	1972 Quantity (short tons)	1972 Approximate equivalent as potash (K_2O) Short tons	1972 Approximate equivalent as potash (K_2O) Percent of total	1972 Value (thousands)	1973 Quantity (short tons)	1973 Approximate equivalent as potash (K_2O) Short tons	1973 Approximate equivalent as potash (K_2O) Percent of total	1973 Value (thousands)
Used chiefly as fertilizers:									
Potassium chloride all grades	60	1,133,977	680,386	87.5	$36,109	1,293,607	776,164	85.8	$44,935
Potassic chemical fertilizer n.e.c	40	200,764	80,306	10.3	9,223	277,750	111,100	12.3	12,825
Natural potassic salt fertilizers, crude	20	18,730	3,746	.5	526	7,359	1,472	.1	237
Total	--	1,353,471	764,438	98.3	45,858	1,578,716	888,736	98.2	57,997
Used chiefly in chemical industries:									
Potassium hydroxide	80	7,033	5,626	.7	990	7,581	6,065	.7	1,221
Potassium peroxide	83	14	12	--	7	24	20	--	23
Potassium compounds, n.e.c	31	24,388	7,560	1.0	5,893	31,624	9,803	1.1	9,416
Total	--	31,435	13,198	1.7	6,890	39,229	15,888	1.8	10,660
Grand total	--	1,384,906	777,636	100.0	52,748	1,617,945	904,624	100.0	68,657

Table 8.—U.S. exports of potash materials, by country

(Short tons and thousand dollars)

Destination	Fertilizer: Chloride quantity 1972	Fertilizer: Chloride quantity 1973	Fertilizer: Chemical fertilizer n.e.c. quantity 1972	Fertilizer: Chemical fertilizer n.e.c. quantity 1973	Fertilizer: Total 1972 Quantity	Fertilizer: Total 1972 Value	Fertilizer: Total 1973 Quantity	Fertilizer: Total 1973 Value	Chemical: Hydroxide (caustic) quantity 1972	Chemical: Hydroxide (caustic) quantity 1973	Chemical: Other n.e.c. quantity 1972	Chemical: Other n.e.c. quantity 1973	Chemical: Total 1972 Quantity	Chemical: Total 1972 Value	Chemical: Total 1973 Quantity	Chemical: Total 1973 Value
Algeria	7,979	--	--	--	7,979	$425	--	--	--	--	18	--	18	$8	--	--
Argentina	6,876	5,909	6,067	8,672	12,943	426	14,581	$565	--	--	270	1,290	270	92	1,290	$176
Australia	76,912	85,315	7,449	9,162	[1] 89,860	[1] 2,637	94,477	3,091	59	48	476	640	535	191	688	399
Belgium-Luxembourg	--	--	440	525	440	16	525	19	24	30	45	499	69	33	529	624
Brazil	394,159	407,021	4,187	10,750	[1] 403,306	[1] 13,092	417,771	14,834	537	1,046	880	8,542	1,417	419	9,588	997
Canada	59,320	1,506	54,576	79,392	[1] 114,063	[1] 4,191	80,898	3,838	4,330	3,171	6,166	6,599	10,496	2,353	9,770	2,216
Chile	20,156	441	--	1,708	20,156	599	2,149	84	--	--	51	78	51	13	78	20
Colombia	31,079	91,266	7,060	139	[1] 39,517	[1] 1,346	91,405	3,240	112	13	6,917	63	7,029	278	76	36
Costa Rica	51,970	43,253	2,810	9,259	54,780	1,798	52,512	1,725	4	2	47	17	51	11	19	5
Dominican Republic	11,896	30,566	366	2,399	12,262	420	32,965	1,328	9	4	950	559	959	88	563	83
Ecuador	3,472	9,883	--	--	3,472	107	9,883	361	11	--	11	2	22	21	2	3
Finland	--	10,521	--	--	--	--	10,521	308	--	--	--	--	--	--	--	--
France	23,821	--	--	--	23,821	843	--	--	--	--	4	1	4	1	1	(3)
Germany, West	--	--	--	--	--	--	--	--	--	113	2,392	2,045	[2] 2,394	[2] 1,051	2,158	1,007
Guatemala	2,753	2,654	125	--	2,878	84	2,654	89	34	19	36	30	70	22	49	18
Honduras	159	40	10	378	169	7	418	14	--	--	452	3	452	23	3	4
India	--	--	--	--	--	--	--	--	--	--	114	49	114	35	49	13
Ireland	--	24,551	--	--	--	--	24,551	844	--	6	5	5	5	1	11	2
Israel	--	--	--	--	--	--	--	--	234	226	1	43	235	39	269	47
Italy	--	--	--	--	--	--	--	--	--	20	12	12	[2] 24	[2] 13	32	18
Jamaica	13,607	14,762	--	19	13,607	362	14,781	528	28	16	12	30	40	15	46	17
Japan	115,901	100,727	50,844	80,650	[1] 170,053	[1] 6,365	[1] 187,439	[1] 8,361	--	--	267	3,225	267	99	[2] 3,243	1,139
Mexico	74,898	72,033	23,814	23,560	98,712	3,105	[1] 96,713	[1] 2,721	1,018	1,438	1,614	2,820	2,632	579	[2] 4,259	1,402
Netherlands	--	16	--	--	--	--	16	1	33	34	101	242	134	62	276	117
Netherlands Antilles	--	--	--	--	--	--	--	--	69	341	--	(3)	69	10	341	84
New Zealand	101,783	243,624	--	--	101,783	3,021	243,624	7,739	--	38	76	135	76	30	173	57
Pakistan	--	--	--	--	--	--	--	--	--	--	388	25	388	94	25	6
Peru	4,739	8,099	1,102	--	5,841	247	8,099	346	28	10	83	120	111	44	130	62
Philippines	23,844	18,491	142	--	[1] 27,333	[1] 822	18,491	603	34	14	77	230	111	50	[2] 249	56
Singapore	6,076	1,488	10,839	3,300	16,915	747	4,788	173	--	--	12	20	12	21	20	55
South Africa, Republic of	42	45	--	--	42	1	45	2	74	510	75	155	149	48	665	195
Sweden	18,990	9,869	--	--	18,990	529	9,869	287	--	--	9	562	9	3	562	44
Taiwan	50,714	65,306	--	4,829	50,714	1,572	70,135	2,395	3	5	274	585	277	64	590	272
U.S.S.R	--	--	--	--	--	--	--	--	--	--	1,103	885	1,103	526	885	319
United Kingdom	--	--	--	--	--	--	--	--	--	142	667	958	667	184	1,100	515
Venezuela	4,888	9,588	--	3,505	4,888	134	[1] 13,129	377	176	272	347	316	523	144	588	246
Vietnam, South	8,370	16,309	4,577	2,903	12,947	789	19,212	1,796	--	--	150	180	150	46	180	45
Other	20,078	20,329	26,356	36,600	[1] 46,505	[1] 2,223	[1] 57,065	[1] 2,328	216	63	286	659	502	179	722	361
Total	1,188,977	1,298,607	200,764	277,750	[1] 1,353,471	[1] 45,858	[1] 1,578,716	[1] 57,997	7,033	7,581	24,388	31,624	[2] 31,485	[2] 6,890	[2] 39,229	[2] 10,660

[1] Includes crude natural potassic salt fertilizer—1972: Canada 167 tons ($5,593), Bahamas 71 tons ($3,125), Colombia 1,878 tons ($45,750), Brazil 4,960 tons ($157,500), Philippines 3,347 tons ($50,205), Japan 3,308 tons ($91,615), Australia 5,499 tons ($171,864). 1973: Bahamas 97 tons ($3,237), Japan 6,602 tons ($201,486), Nicaragua 39 tons ($1,320), Mexico 1,120 tons ($29,180), Venezuela 41 tons ($1,380).

[2] Includes potassium peroxide—1972: West Germany 2 tons ($1,770), Italy 12 tons ($5,128), 1973; Japan 18 tons ($17,966), Mexico 1 ton ($680), Philippines 5 tons ($4,288).

[3] Less than ½ unit.

Table 9.—U.S. imports for consumption of potash materials, by use

Materials	Approximate equivalent as potash (K_2O), percent	1972 Quantity (short tons)	1972 Approximate equivalent as potash (K_2O) Short tons	1972 Approximate equivalent as potash (K_2O) Percent of total	1972 Value (thousands)	1973 Quantity (short tons)	1973 Approximate equivalent as potash (K_2O) Short tons	1973 Approximate equivalent as potash (K_2O) Percent of total	1973 Value (thousands)
Used chiefly as fertilizers:									
Muriate (chloride)	60	4,858,740	2,915,244	98.2	$113,611	5,898,988	3,539,393	98.3	$137,691
Potassium nitrate, crude	40	20,885	8,354	.3	1,673	48,195	19,278	.5	3,101
Potassium sodium nitrate mixtures, crude	14	27,823	3,895	.1	1,447	53,280	7,459	.2	2,737
Potassium sulfate, crude	50	65,615	32,806	1.1	2,798	54,524	27,262	.8	2,636
Other potash fertilizer material	6	5,587	335	--	137	8,757	525	--	271
Total	--	4,978,650	2,960,634	99.7	119,666	6,063,744	3,593,917	99.8	146,436
Used chiefly in chemical industries:									
Bicarbonate	46	1,063	489		128	996	458		175
Bitartrate:									
Argols	20	11	2		4	--	--		--
Cream of tartar	25	1,173	293		731	1,113	278		748
Carbonate	61	1,518	926		213	1,747	1,066		296
Caustic	80	1,562	1,250		360	1,052	842		295
Chlorate and perchlorate	36	432	156	.3	119	517	186	.2	129
Cyanide	70	825	578		364	732	512		360
Ferricyanide	42	1,028	432		728	708	297		585
Ferrocyanide	44	999	440		416	913	402		441
Nitrate	50	2,220	1,110		300	704	352		97
Rochelle salts	22	492	108		229	482	106		266
All other	31	6,442	1,997		5,290	9,736	3,337		7,972
Total	--	17,765	7,781	.3	8,882	18,700	7,836	.2	11,364
Grand total	--	4,996,415	2,968,415	100.0	128,548	6,082,444	3,601,753	100.0	157,800

Table 10.—U.S. imports for consumption of potash materials, by country

(Short tons)

Year and country	Bitartrate cream of tartar	Caustic (hydroxide)	Chlorate and perchlorate	Cyanide	Muriate (chloride)	Potassium nitrate crude	Potassium sodium nitrate mixtures, crude	Potassium nitrate (saltpeter) refined	Potassium sulfate	All others	Total: Quantity	Total: Value (thousands)
1972:												
Belgium-Luxembourg	--	--	--	--	14	--	--	--	80	428	522	$284
Canada	--	--	--	6	4,635,679	57	168	--	60	6,019	4,641,989	107,330
Chile	--	--	--	--	6,983	3,525	10,913	--	--	--	21,421	927
Congo (Brazzaville)	--	--	--	--	33,856	--	--	--	--	--	33,856	1,047
Finland	--	--	--	--	--	--	--	--	--	904	904	104
France	6	63	--	--	--	90	--	--	23,211	1,340	24,710	1,302
Germany, West	--	360	--	443	52	--	--	416	42,239	4,190	47,700	4,080
Israel	--	--	--	--	176,280	17,112	10,071	1,563	--	--	205,026	7,979
Italy	752	--	--	--	--	--	--	199	--	92	1,043	571
Japan	--	615	--	161	--	101	--	--	--	1,754	2,631	2,801
Netherlands	--	--	--	--	--	--	--	--	--	1,676	1,676	569
Norway	--	--	--	--	--	--	6,671	--	--	--	6,671	285
Spain	415	--	--	--	--	--	--	--	--	307	722	440
Sweden	--	524	266	--	--	--	--	--	--	(1)	790	251
United Kingdom	--	--	--	215	(1)	--	--	--	--	361	576	307
Zaire	--	--	--	--	5,274	--	--	--	--	--	5,274	151
Other	--	--	166	--	602	--	--	42	25	69	904	120
Total	1,173	1,562	432	825	4,858,740	20,885	27,823	2,220	65,615	17,140	4,996,415	128,548
1973:												
Belgium-Luxembourg	--	--	--	3	--	--	--	--	--	652	655	404
Brazil	--	--	--	--	11,629	--	--	--	--	--	11,629	288
Canada	4	--	--	4	5,808,606	568	329	--	--	9,168	5,818,679	136,033
Chile	--	--	--	--	--	--	31,534	--	--	--	31,534	1,447
Congo (Brazzaville)	--	--	--	--	6,007	--	--	--	--	--	6,007	177
Finland	--	--	--	--	--	--	--	--	--	1,824	1,824	226
France	--	50	--	1	3,000	5,032	--	--	20,660	1,336	30,079	1,862
Germany, West	--	263	--	465	--	--	--	39	33,864	4,005	38,636	3,932
Israel	--	--	--	--	44,380	14,914	10,415	665	--	14	70,388	4,030
Italy	729	--	--	--	--	--	--	--	--	94	823	543
Japan	--	204	--	125	--	--	--	--	--	2,183	2,512	4,116
Netherlands	--	--	3	--	7,398	--	--	--	--	3,006	10,407	1,201
Netherlands Antilles	--	--	--	--	--	9,421	--	--	--	--	9,421	358
Norway	--	--	--	--	--	--	11,002	--	--	--	11,002	484
Spain	340	--	199	--	17,968	--	--	--	--	362	18,869	1,082
Sweden	--	469	262	--	--	--	--	--	--	(1)	731	250
Trinidad and Tobago	--	--	--	--	--	18,260	--	--	--	--	18,260	767
United Kingdom	--	46	--	134	--	--	--	--	--	619	799	464
Other	40	20	53	--	--	--	--	--	--	76	189	146
Total	1,113	1,052	517	732	5,898,988	48,195	53,280	704	54,524	23,339	6,082,444	157,800

[1] Less than ½ unit.

WORLD REVIEW

World production increased strongly in 1973, as new mines were opened in Australia and the United Kingdom. Several older European mines were closed.

Australia.—Texada Mines Pty. Ltd. was to begin production of langbeinite from evaporite deposits at Lake McLeod, north of Perth, Western Australia, in the third quarter. A plant was planned with an initial capacity of about 80,000 tons per year, but it was decided to increase this to 200,000 tons, with a possible expansion to 300,000 tons. The bulk of production will be exported, making Australia the world's largest exporter of this product.[2]

Brazil.—Petroquisa and the Lume group announced that they would invest about $120 million over a period of 6 years to produce potash at Carmópolis, in the State of Sergipe, northeastern Brazil. A minority shareholder will be the National Economic Development Bank (BNDE).[3] A local company, Kalium Mineraçãoes, has reportedly received permission to exploit the potash deposit.[4]

Canada.—A study of the Canadian potash industry was issued to serve as background material for an analysis of the transportation of Canadian potash.[5] After an outline of the development and growth of the industry, the basis for prorationing production to market demand was discussed. Prorationing instituted by the Government of Saskatchewan is policed by the producers themselves. All producers operate at a similar capacity level, set to total 95% of the estimated market; the basic industry allowance in the 1973 fertilizer year was 47.7% of capacity, and the total average was about 52%. Excess markets are shared among producers. Exceptions that increased the average above the basic allotment included a special arrangement by one producer to sell 300,000 to 400,000 tons per year to a U.S. firm, a share of which was given to other producers until June 1973, and the building up of stocks by several producers. The minimum price of Can $20.25 per short ton of 60% K_2O product (equivalent to 33.75 cents per unit) may not absorb freight demurrage or storage charges, except storage at Vancouver, which is considered an extension of mine stockpiles.

Prorationing quotas for the fertilizer year 1974, issued late in 1973, allowed the industry to produce 5.6 million tons of K_2O, including 40,000 tons to rebuild inventory, or a rate of about 68% of nominal capacity. This was expected to bring Canadian production in line with its share of world capacity.

France.—Completion of a program of production rationalization in the Alsace potash mines was scheduled to reduce the number of mines to three: Théodore, Amélie, and Marie-Louise, with eventual capacities of 1,760, 1,870, and 2,650 (3,200 by 1974) short tons per day of K_2O in product. Rationalization and modernization were first envisioned in the late 1960's as necessary to meet Canadian expansion into world markets. Total annual capacity of 2.05 to 2.1 million short tons of K_2O will be maintained.[6]

The Anna mine was closed in August, after 51 years of operation. The average grade of ore extracted during the last year was 14% K_2O.[7]

Germany, West.—The Buggingen mine of Kali und Salz AG ceased operations on April 30.[8] The mine in Baden Württemburg was the last remaining in the south German extension of the Alsace deposits; it had a capacity of 495,000 to 550,000 short tons per year.

Italy.—After the Sicilian potash industry was unified late in 1972,[9] two producers, both controlled by the Italian and Sicilian Governments, were in operation. One, SALSI (Societá Salisera Siciliana), produced potassium sulfate from kainite ore, with its principal mine at Palo (San Cataldo), and its refinery at Campofranco; the other, ISPEA (Industria Sali Potassici e Affini, S.p.A.), produced potassium chloride from carnallite, with its principal mine and refinery at Pasquasia. SALSI plans to expand production at Racalmuto, and ISPEA

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[2] Phosphorus and Potassium. Langbeinite From Western Australia. No. 65, May–June 1973, pp. 41–42.

[3] American Consulate General, Saõ Paulo, Brazil. State Department Airgram A-76, November 1973, p. 8.

[4] Industrial Minerals. No. 70, July 1973, p. 39.

[5] Litvack, B. M. The Canadian Potash Industry. Canadian Transport Commission Report 62, September 1973, 65 pp.

[6] Phosphorus and Potassium. The French Potash Industry. No. 65, May–June 1973, pp. 36–40.

[7] Phosphorus and Potassium. No. 67, September–October 1973, p. 14.

[8] Chemical Age International. German Potash Plant to Close in April. V. 106, No. 2800, Mar. 16, 1973, p. 21.

[9] Phosphorus and Potassium. The Italian Potash Industry. No. 63, January–February 1973, pp. 36–40.

was slated to start potassium sulfate production at Pasquasia in 1973.

Libya.—The Industrial Research Centre of the Libyan Arab Republic issued a tender for technical and marketing know-how to assist with the exploitation of the Marada salt occurrence in central Libya, 120 miles by road south of the Gulf of Sirte. The area is a salt marsh, with a crust varying between 14 and 22 inches in thickness; the brines that form it contain up to 2% potassium. The deposits were worked in 1939–40 by an Italian consortium, when about 23,000 short tons containing 40% to 42% K_2O was produced by fractional recrystallization.[10]

U.S.S.R.—A summary of potash reserves in the U.S.S.R., based on a review of recent Soviet literature, was published.[11] Total reserves of all degrees of confidence were given as 28,410 million short tons containing 16% to 40% K_2O. This includes 17,500 million tons of carnallite and sylvite with 13% to 20% K_2O in the Upper Kama basin in the northern Urals; 5,070 million tons of sylvinite containing 16% to 20% K_2O in Starobinsk, Belorussia; and 3,200 million tons, largely of hartsalz, containing 16% K_2O in L'vov Oblast, Western Ukraine. Other reserves in the Karlyukskoye deposit in the Turkmen SSR were reported as 2,200 million tons and in the Tuva-Gatanskoye deposit, 440 million tons. The Petryakovskoye deposit in Belorussia was under exploration in 1972.

United Kingdom.—Commercial production from Britain's first potash mine began in the second half of 1973.[12] Maximum output at the rate of 1 million tons of K_2O was expected to be reached during 1974 from the Boulby, Yorkshire, mine of Cleveland Potash Co., Ltd.

Table 11.—Marketable potash: World production by country

(Thousand short tons, K_2O equivalent)

Country	1971	1972	1973 p
Canada	4,000	3,852	4,432
Chile	34	26	e 28
China, People's Republic of e 1	230	310	330
Congo (Brazzaville)	r 288	317	e 350
France	2,204	1,940	2,494
Germany, East	2,674	2,709	e 2,910
Germany, West	p 3,103	3,136	e 3,300
Israel	r 624	618	e 600
Italy	236	238	e 225
Spain	666	703	e 640
U.S.S.R	5,299	5,989	e 6,300
United States	2,587	2,659	2,603
Total	r 21,945	22,497	24,212

e Estimate. p Preliminary. r Revised.
1 Data for year ending June 30 of that stated.
Source: British Sulphur Corp. Ltd. Statistical Supplement No. 8, November–December 1973. London, 1973, pp. 18–19.

TECHNOLOGY

A $1 million project to produce alumina and potash from alunite was dedicated at Golden, Colo., by a group composed of Earth Sciences, Inc., Golden, Colo.; National Steel Corp., Pittsburgh, Pa.; and Southwire Co., Carrollton, Ga. The Alunite Metallurgical Center is part of a program to test the process on a pilot-plant scale. If successful, the project could lead to the production of 500,000 tons of alumina, 250,000 tons of potash, and 450,000 tons of sulfuric acid yearly from the joint venture's property near Cedar City, Utah.[13]

The Federal Bureau of Mines continued its investigations of methods to concentrate potash minerals. Tests were made on a flotation process for economically recovering potash from high-clay ores, in a mobile field testing unit at the Duval Corp. mine in New Mexico. Methods were studied at the Tuscaloosa Metallurgy Research Laboratory, Tuscaloosa, Ala., to improve brine recovery from slimes generated in processing potash ore. During the year research was started at the Salt Lake

10 Phosphorus and Potassium. Libya—Assistance Required To Develop Potash Resources. No. 63, January–February 1973, p. 41.

11 Strishkov, V. V. Soviet Union. Min. Ann. Rev., (suppl. to Min. J., London), July 20, 1973, p. 435.

12 Engineering and Mining Journal. Britain's First Major Potash Mine Comes On Stream. V. 174, No. 11, November 1973, pp. 139–140.

13 Chemical Marketing Reporter. "Alumina-ex-Alunite Project Gets Under Way." V. 204, No. 25, Dec. 17, 1973, pp. 5, 13.

City Metallurgy Research Center, Salt Lake City, Utah, to prepare chemical plant feed enriched in potassium sulfate from crude salt from Great Salt Lake brine. Bench-scale flotation tests demonstrated the possibility of concentrating the salts from 5% or 6% potassium to 12% or 14% potassium at recoveries ranging from 75% to 90%. Also at Tuscaloosa, the Bureau demonstrated that concentrates containing 59.9% K_2O can be made from New Mexico high-clay sylvinite ores by heavy-liquid separation at recoveries of over 75%[14]

The Office of Coal Research of the Department of the Interior, and the National Aeronautics and Space Administration sponsored research by the General Electric Co. into the use of potassium topping cycles for stationary powerplants. Efficiency of central station powerplants would be increased by boiling potassium instead of water. Maximum steam temperature is limited at present to about 1,000° F.; potassium could permit temperatures as high as 1,700° F., at substantially lower pressures than steam.[15]

It was also reported that an attractive gasification system for magnetohydrodynamic (MHD) power generation consists of a bed of molten potassium carbonate. Some potassium carbonate is carried over to the combustor, where it reduces the need to add potassium carbonate seed.[16]

The Federal Bureau of Mines determined that mixed seedling of 15 mole-percent cesium carbonate and 85 mole-percent potassium carbonate was preferable to either pure cesium or potassium carbonates in open cycle MHD power generation.[17]

In a trial of Lurgi gasification of American coal, in Westfield, Scotland, it was intended to test sulfur purification of the synthesis gas with the Benfield process, using hot potassium carbonate, replacing the Lurgi Rectisol process.[18] The Benfield process is based on the HPC (hot potassium carbonate) process developed by the Federal Bureau of Mines in the 1950's.

Drilling fluids inhibited with potassium chloride were found effective in stabilizing sensitive shales in oil well drilling. Two cations, potassium and ammonium, were found far superior to others as such inhibiting agents, but potassium was preferred for field use because it was less expensive and more temperature stable.[19]

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[14] Liles, K. J., J. W. Brown, and G. V. Sullivan. Continuous Heavy Liquid Concentration of High-Clay Potash Ores. BuMines RI 7724, 1973, 14 pp.

[15] Office of Coal Research (U.S. Department of the Interior). Annual Report, 1973–74. Coal Technology: Key to Clean Energy. 1974,, p. 56.

[16] Page 62 of work cited in footnote 15.

[17] Bergman, P.D., and D. Bienstock. Mixed Potassium-Cesium Seeding in Open-Cycle MHD Power Generation. 13th Symp. Eng. Aspects of Magnetohydrodynamics, Stanford Univ., Palo Alto, Calif., Mar. 26–28, 1973, pp. V.5.1–V.5.6.

[18] Levene, H. D. Gasification or Liquefaction: Where We Stand. Coal Min. and Processing, V. 11. No. 1, January 1974, pp. 43–48.

[19] O'Brien, D. E. and M. E. Chenevert. Stabilizing Sensitive Shales With Inhibited, Potassium-Based Drilling Fluids. J. Petrol. Technol., v. 25, September 1973, pp. 1089–1100.

Pumice and Volcanic Cinder

By Arthur C. Meisinger [1]

U.S. production of pumiceous materials in 1973 declined 1% in quantity but increased 34% in value compared with that of 1972. The record value of nearly $8.8 million for pumice, pumicite, and volcanic cinder sold or used by producers in 1973 was due, in large part, to the continued increase in costs for milling. Increased consumption of pumice and volcanic cinder as landscaping material emerged in 1973, and exceeded 150,000 tons, although comprising only 4% of the total use pattern. A record quantity of nearly 3,100 tons of pumice was exported to meet the growing demand in Europe, particularly in West Germany; however, pumice imports declined significantly (48%) in 1973 from that of 1972, primarily because of major price increases for foreign grades.

DOMESTIC PRODUCTION

Domestic production of pumiceous materials was 3,772,000 tons in 1973, down 1% from the 3,813,000 tons in 1972. However, the value increased 34% from $6,539,000 in 1972 to $8,770,000 in 1973. The increase in total value of pumiceous materials was attributed to increased pumice and pumicite production (824,000 tons and $3.6 million) in 1973, which was the highest reported since 1964 when nearly 1.2 million tons of pumice valued at $4.1 million was produced. Although the quantity of volcanic cinder, ash, and scoria was down about 75,000 tons from that of 1972, the value increased 11% in 1973. Volcanic cinder, ash, and scoria comprised 78% of the U.S. output of pumiceous materials.

Domestic output in 1973 came from 88 firms, individuals, and governmental agencies producing from 158 operations in 13 States. Compared with 1972, output of pumiceous materials in 1973 came from 13 less producers and 62 fewer operations. The principal producing States, in order of output as in 1972, were Oregon, Arizona, and California, and their combined output accounted for 70% of the national total. Other States with significant output of pumiceous materials were Hawaii, Nevada, and New Mexico. Of the six leading States, only Arizona and Hawaii showed a decrease in production from that of 1972. California led all the producing States with 56 active operations, followed by Oregon with 31, and Arizona with 28. Volcanic cinder was produced in 11 of the 13 States, and in American Samoa from deposits operated by the Samoan Government.

[1] Industry economist, Division of Nonmetallic Minerals—Mineral Supply.

Table 1.—Pumice, pumicite, and volcanic cinder sold or used in the United States [1]
(Thousand short tons and thousand dollars)

Year	Pumice and pumicite		Volcanic cinder		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1969	598	1,349	3,011	3,701	3,609	5,050
1970	490	1,233	2,546	3,438	3,036	4,671
1971	540	1,396	2,851	3,818	3,391	5,214
1972	790	1,878	3,023	4,661	3,813	6,539
1973	824	3,612	2,948	5,158	3,772	8,770

[1] Values f.o.b. mine, (1969–71); value f.o.b. mine or mill, 1972 and 1973.

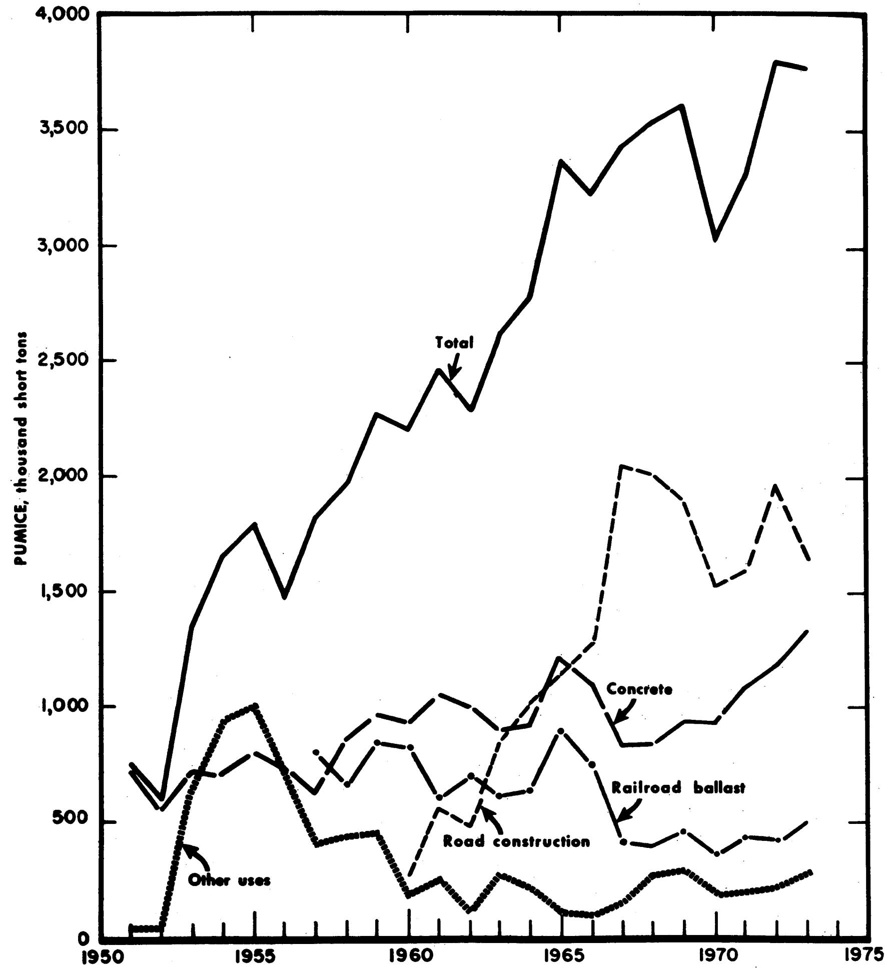

Figure 1.—Pumice and volcanic cinder sold or used by producers in the United States by use.

Table 2.—Pumice, pumicite and volcanic cinder sold or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1972 Quantity	1972 Value	1973 Quantity	1973 Value
Arizona	915	722	853	715
California	731	1,507	768	3,237
Colorado	59	W	W	W
Hawaii	379	762	354	611
Idaho	W	W	80	110
New Mexico	311	809	339	1,001
Oregon	923	1,512	1,006	1,902
Utah	14	r 29	42	57
Washington	W	W	1	1
Other States [1]	482	1,199	328	1,136
Total [2]	3,813	6,539	3,772	8,770
American Samoa	6	27	37	214

r Revised. W Withheld to avoid disclosing individual company confidential data; included with "Other States."

[1] Colorado (value 1972), Idaho (1972), Kansas, Nebraska (1972), Nevada, North Dakota (1972), Oklahoma, Texas (1972), Washington (1972), and Wyoming.

[2] Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Road construction (including ice control and road maintenance) and concrete admixtures and aggregates were again the major end uses of pumiceous materials, and accounted for 44% and 35%, respectively, of U.S. consumption in 1973. Of the remaining 21%, railroad ballast comprised 13%, landscaping 4%, and abrasive materials and other uses, 4%.

Compared with consumption in 1972, use in landscaping increased 33%; use in railroad ballast, 20%; use in concrete admixtures and aggregates, 10%; and other uses, 29%. Use in road construction declined 16% from that of 1972, and use in abrasives declined 5% in 1973. The completion of a number of highway contracts in the western United States at the beginning of 1973 was reflected in a decrease in the use of volcanic cinder for road construction.

Table 3.—Pumice, pumicite, and volcanic cinder sold or used by producers in the United States, by use

(Thousand short tons and thousand dollars)

Use	1972 Quantity	1972 Value	1973 Quantity	1973 Value
Abrasive—(cleaning and scouring compounds)	21	207	20	541
Concrete admixture and concrete aggregate	1,197	2,406	1,320	2,948
Landscaping	115	584	153	770
Railroad ballast	421	391	504	529
Road construction (includes ice control and maintenance)	1,963	2,310	1,651	2,104
Other uses [1]	r 97	r 641	125	1,878
Total [2]	3,813	6,539	3,772	8,770

r Revised.

[1] Includes miscellaneous abrasive uses (1972), absorbents, heat-or-cold insulating medium, roofing, and miscellaneous uses.

[2] Data may not add to totals shown because of independent rounding.

PRICES

The average value for crude pumice, pumicite, and volcanic cinder sold and used decreased slightly from $0.98 per ton in 1972 to $0.95 per ton in 1973. Average value for prepared material, however, showed a significant increase—from $2.42 per ton in 1972 to $3.60 per ton. The weighted average value of pumice, pumicite, and volcanic cinder was $2.33 per ton compared with $1.71 per ton in 1972. The continued increased costs in milling was primarily responsible for the rise in weighted average value of pumiceous materials.

The average 1973 price per ton for pumice and volcanic cinder (scoria) used in cleaning and scouring compounds was $27.05, substantially above the 1972 price; for concrete admixtures and aggregates, $2.23, a $0.22 increase; for railroad ballast $1.05, a $0.12 increase; for road construction, $1.27, a $0.09 increase; and for other uses, $15.02, an $8.41 increase. Pumice and volcanic cinder used for landscaping decreased $0.05 in price per ton in 1973 from $5.08 in 1972 to $5.03.

Prices quoted at yearend in the American Paint Journal remained unchanged from 1972, and were as follows for pumice stone per pound, bagged, f.o.b. New York or Chicago: Powdered, $0.0445 to $0.08, and lump, $0.0665 to $0.09.

Price quotations for pumice in Chemical Marketing Reporter were changed on May 21, 1973, and at yearend were as follows: Domestic grades, bagged in ton lots, fine, $0.0765 to $0.1140 per pound; medium, $0.1160 per pound; coarse, $0.094 per pound; imported (Italian) silk-screened, bagged in ton lots, fine, $138 per ton; medium, $150 per ton; and coarse, $140 per ton. Price of imported small and large lump size was reported as $275 per ton.

FOREIGN TRADE

A record quantity of 3,095 tons of pumice was exported in 1973. Since 1965, when export data were first available, the previous record was only 624 tons of pumice in 1968. Pumice was exported to 16 countries in 1973—4 more countries than in 1972—West Germany received 79% (2,457 tons) of the total pumice exported.

Pumice imported for consumption declined in 1973, due primarily to increased shipping rates, higher prices of foreign pumice, and a fuel shortage that reduced cargo shipments at yearend. Compared with 1972, imports of pumice declined 48% in quantity and 24% in value. As in previous years, Italy and Greece supplied nearly all of the imported pumice. Total value of all import classes was $1.1 million in 1973 compared with $1.5 million in 1972.

Imported pumice used in the manufacture of concrete masonry products declined 48% from that of 1972, and imports classed as crude or unmanufactured declined 45%. However, imports classed as wholly or partly manufactured increased 10% from 2,489 tons in 1972 to 2,740 tons in 1973.

Pumice stone, TSUS No. 519.05, for use in concrete products continued to be admitted into the United States duty free. Duties for other products at yearend were as follows: TSUS No. 519.11, crude or crushed pumice, valued not over $15 per ton, 0.02 cent per pound; TSUS No. 519.14, crude or crushed pumice, valued over $15 per ton, 0.04 cent per pound; TSUS No. 519.31, grains or ground, pulverized or refined, 0.17 per pound; and TSUS Nos. 519.93 and 523.61, millstones, abrasive wheels, and abrasive articles n.s.p.f. and articles, n.s.p.f., 7% ad valorem.

Table 4.—U.S. exports of pumice

Year	Quantity (short tons)	Value (thousands)
1970	304	$70
1971	357	51
1972	256	34
1973	3,095	765

Table 5.—U.S. imports for consumption of pumice, by class and country

Country	Crude or unmanufactured		Wholly or partly manufactured		Used in the manufacture of concrete masonry products		Manufactured n.s.p.f.
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Value (thousands)
1972:							
Greece	--	--	--	--	257,759	$544	--
Italy	9,094	$149	2,489	$149	329,510	657	$19
Mexico	--	--	(1)	1	--	--	--
Other [2]	--	--	--	--	--	--	5
Total	9,094	149	2,489	150	587,269	1,201	24
1973:							
Greece	--	--	--	--	193,922	501	--
Italy	5,026	95	2,740	215	108,738	321	4
Mexico	--	--	(1)	1	--	--	--
Other [3]	--	--	--	--	--	--	15
Total	5,026	95	2,740	216	302,660	822	19

[1] Less than ½ unit.
[2] Canada, Hong Kong, Estonia, West Germany, Japan.
[3] Canada, the People's Republic of China, France, West Germany, Japan, the U.S.S.R., and the United Kingdom.

Table 6.—Pumice and related volcanic materials: World production, by country

(Thousand short tons)

Country [1]	1971	1972	1973 [p]
Argentina [2]	21	[e] 20	[e] 20
Austria: Pozzolan	36	31	27
Cape Verde Islands: Pozzolan	10	[e] 11	[e] 11
Chile: Pozzolan	161	175	157
Dominica [e]	[r] 33	[r] 33	33
Egypt, Arab Republic of	(3)	(3)	(3)
France:			
Pumice	1	[e] 1	[e] 1
Pozzolan and lapilli	[r] 844	691	[e] 717
Germany, West (marketable)	5,534	5,534	4,199
Greece:			
Pumice	462	589	[e] 590
Pozzolan	675	724	[e] 728
Guadeloupe: Tuff (pozzolanic) [e]	50	50	50
Guatemala: Volcanic ash (for cement) [e]	50	[r] 29	33
Iceland	26	[4] 19	21
Italy:			
Pumice and pumiceous lapilli	[r] 926	[r e] 1,000	[e] 1,000
Pozzolan	3,924	[r e] 4,400	[e] 4,000
Martinique: Pumice [e]	20	20	20
New Zealand	14	143	[e] 143
Spain [5]	172	[r e] 176	[e] 176
United States (sold or used by producers):			
Pumice and pumicite	540	790	824
Volcanic cinder [6]	2,861	3,029	2,948
Total	[r] 16,360	17,465	15,698

[e] Estimate. [p] Preliminary. [r] Revised.
[1] Pumice is also produced in Iran, Japan, Mexico, Turkey and the U.S.S.R. (sizable), but data on quantities are not available.
[2] Unspecified volcanic materials produced mainly for use in construction products.
[3] Less than ½ unit.
[4] Exports.
[5] Includes Canary Islands.
[6] Includes American Samoa.

Rare-Earth Minerals and Metals

By James H. Jolly [1]

Total world production of rare-earth oxide (REO) contained in concentrates increased about 25% in 1973 despite decreased output by the two leading monazite producing countries, Australia and India. The major factor in the increase was a 64% jump in bastnaesite production at Mountain Pass, Calif., by the Molybdenum Corp. of America (Molycorp). In 1973, Molycorp produced an estimated 60% of the total world REO output. Foreign mine production of rare-earth minerals decreased slightly from last year's level due to power and water shortages and, in part, to decreasing monazite grade at some mines. Monazite was in short supply during the year and prices increased about 15%. Worldwide, the production and consumption of rare-earth compounds and metals increased.

The domestic rare-earth industry was highlighted in 1973 by record production of rare-earth concentrates, increased mine and mill capacity, increased shipments and exports of rare-earth materials, and promising technological developments. The consumption pattern of rare earths changed from that of the previous year. Petroleum catalyst usage was the major consumer of rare earths in 1973, replacing metallurgical applications by a wide margin. Metallurgical uses declined about 20% mainly because rare-earth silicide demand was markedly lower.

U.S. exports of rare-earth products exceeded 8,000 tons contained REO, double the 1972 content. The major importing countries were Japan, West Germany, France, Austria, Canada, and the United Kingdom.

Domestic imports of monazite increased and receipts of yttrium-rich uranium residues from Canada were resumed. Demand for ytruim oxide for use in color television phosphors balanced chronic oversupply conditions for the first time since 1968. U.S. chemical processing capacity decreased during the year because two major rare-earth processors, Lindsay Rare Earths Div. of Kerr-McGee Corp. and Michigan Chemical Co., ceased operations and were dismantling facilities.

Legislation and Government Programs.—At the end of 1973, the General Services Administration (GSA) held a total of 11,677 short tons (dry) of REO equivalent in the national (9,574 tons) and supplemental (2,103 tons) stockpiles. Disposals for the year amounted to 140 tons of contained REO in rare-earth chloride. The Y_2O_3 stockpile remained unchanged at 237 pounds. The rare-earth elements were removed from the list of strategic and critical materials in March 1971 and were authorized for orderly disposal to industry.

During 1973, the Office of Minerals Exploration (OME), U.S. Geological Survey, continued financial assistance of 50% of approved costs for exploration for rare-earth and yttrium resources.

DOMESTIC PRODUCTION

Concentrate.—REO production as measured by output of bastnaesite and monazite was at an alltime high in 1973 and about 60% higher than that of 1972. More than 90% of production was in the form of bastnaesite; the remainder was in the form of monazite.

The Mountain Pass, Calif., operation of Molycorp produced 19,341 tons of REO in flotation concentrate from 305,073 tons of bastnaesite ore mined and milled. A 50% expansion of mill and flotation facilities to

[1] Physical scientist, Division of Nonferrous Metals—Mineral Supply.

30,000 tons REO annually, announced in January, was completed in the fourth quarter.[2]

Molycorp extended its option with Republic Steel Corp. for exclusive purchase rights to heavy rare-earth and yttrium concentrates which may be recovered from the apatite in tailings at Republic's iron ore property at Mineville, N.Y. A low-cost, acid-heap-leaching method to extract yttrium from these tailings was under investigation by the Bureau of Mines.

Humphreys Mining Co. continued to recover byproduct monazite from a beach sand deposit controlled by E. I. du Pont de Nemours & Co., near Folkston, Ga. Ore reserves at the deposit are expected to be exhausted by mid–1974. However, the company planned to continue operations by developing another beach sand deposit located a few miles south, in Florida. The heavy mineral concentrate from the new deposit will be processed at the existing Folkston plant.

Titanium Enterprises, jointly owned by American Cyanamid Co. and Union Camp Corp., was the only other domestic producer of monazite in 1973. The company, which began operations in October 1972, produced monazite as a byproduct in mining Pleistocene beach sands for titanium minerals and zircon near Green Cove Springs, Fla. In the latter part of the year, production decreased due, in part, to energy shortages.

Compounds and Metals.—With the closing of the Lindsay Rare Earths Div. of Kerr-McGee Corp. (Lindsay), West Chicago, Ill., only two volume rare-earth processors, Molycorp and the Davison Chemical Div. of W. R. Grace & Co. (Davison), Chattanooga, Tenn., were operating at the end of 1973. Lindsay, a pioneer in the rare-earth industry, ceased all operations during the year and was dismantling facilities and selling off stocks. The plant, which had an annual capacity of several million pounds, processed monazite into a wide range of rare-earth chemicals and polishing compounds. Michigan Chemical Corp., St. Louis, Mich., specialty producers of yttrium and heavy rare-earth compounds, also ceased rare-earth production in 1973. The company was dismantling all of its ion-exchange facilities and was also selling off rare-earth stocks.

Molycorp, with processing plants at Mountain Pass, Calif., Louviers, Colo., Washington, Pa., and York, Pa., increased production of rare-earth compounds 56% (in terms of REO) over that of 1972. Molycorp resumed importation of yttrium-rich uranium residues from Denison Mines, Ltd., Canada, in 1973 for processing at the Louviers plant after a 3-year suspension of imports because of oversupply conditions. The plant had produced yttrium oxide in the interim from stockpiled residues.

High-purity rare-earth oxides and compounds were produced by Molycorp; Lindsay; Davison ; Michigan Chemical Corp.; Research Chemicals Div., Nucor Corp., Phoenix, Ariz.; Atomergic Chemetals Co., Div. of Gallard-Schlesinger Chemical Manufacturing Corp., Carle Place, N.Y.; and by Transelco Inc., Penn Yan, N.Y. Lindsay, Molycorp, Michigan Chemical, Research Chemicals, and Atomergic produced yttrium oxide and/or metal during the year.

Mischmetal production by the two primary domestic producers—Ronson Metals Corp., Newark, N.J., and Reaction Metals Inc., Newcastle, Pa., a subsidiary of Rare Earth Industries—increased 17% but shipments decreased more than 30% indicating less metallurgical consumption. Rare Earth Metals Co. of America, a joint venture of Aluminum Co. of America (51%) and Molycorp (49%), continued pilot plant testing of a Bureau of Mines-developed electrolytic reduction process to produce mischmetal and rare-earth metals at Molycorp's Washington, Pa., facility. A plant with an annual capacity of 250 tons of metal was planned for 1975.

Rare-earth ferrosilicon alloys consumed primarily by the iron and steel industry in the United States and Canada were produced by four companies: Foote Mineral Co., Ohio Ferro-Alloys Corp., American Metallurgical Products Co., Inc., and Union Carbide Corp. Production and shipments were sharply lower in 1973.

Crucible Magnetics Div. of Colt Industries, Inc., Elizabethtown, Ky., became the fifth domestic producer of rare earth-cobalt magnets in December.[3] Other producers were Raytheon Co., Waltham, Mass.; Spectra-Flux Corp., Watsonville, Calif.; Elec-

[2] American Metal Market. Molycorp Expanding Calif. Rare-Earth Unit. V. 80, No. 16, January 1973, p. 15.

[3] American Metal Market. Small, Powerful Magnet Available in 3 Strengths. V. 80, No. 238, Dec. 10, 1973, p. 25.

tron-Energy Corp., Landisville, Pa.; and Hitachi Magnetics Corp., Edmore, Mich. Hitachi acquired the magnetic materials facilities of General Electric Co. in March and began commercial production at midyear.[4]

CONSUMPTION AND USES

Domestic rare-earth processors consumed an estimated 19,700 tons of REO contained in raw materials during 1973. Bastnaesite consumption increased 45% while monazite consumption decreased by almost 27%. Consumption of monazite by W. R. Grace at Chattanooga, Tenn., declined slightly, whereas bastnaesite consumption, although considerably less than that of monazite, almost tripled.

Shipments of rare-earth and yttrium products from principal processing plants to domestic consumers totaled about 13,400 tons REO, valued at about $23 million. This quantity includes intracompany shipments but does not include products derived from reprocessed shipments at secondary plants. The following estimated quantitative percentage distribution of rare-earth product usage during 1973 was based on information supplied by primary processors and certain consumers: Petroleum cracking catalysts, 43%; metallurgical, including nodular iron and steel, other alloys, magnets, and lighter flints, 35%; ceramics and glass, 17%; electrical and arc light carbons, 4%; and miscellaneous, including research and development, 1%. Shipments of high purity rare-earth and yttrium oxides and metals, although representing less than 1% of the total weight of shipments, accounted for about 30% of the value.

The manufacture of rare-earth zeolites for use in petroleum cracking catalysts replaced metallurgical uses as the major consumer of rare earths in 1973. Metallurgical consumption declined mainly because demand for rare earths used in the production of pipeline steel was significantly lower, owing to continuing delays in construction of the Alaskan pipeline. Most other metallurgical applications, however, continued to increase. Stimulated by the automobile industry's need to reduce the weight of automobiles, the consumption of rare earths in the production of high-strength, low-alloy (HSLA) sheet steels doubled in 1973. Rare earths, in the form of mischmetal or silicide, added to such steels, increase impact and yield strength and improve weldability and formability by beneficially influencing the number, size, shape, and composition of retained inclusions. With proper design, the use of HSLA steels can reduce the weight of some automobile components by as much as 30%.[5] A large increase in metallurgical consumption of rare earths was expected in 1974 owing to large-scale production of HSLA steel for Arctic pipeline construction. Rare-earth treated HSLA steel alloys possess the rigid physical properties required for this pipe to withstand the internal pressures and extreme temperature variations of Arctic regions.

Rare earths were widely used in the production of ductile cast iron because they counteract a number of deleterious elements that interfere with the activity of magnesium in producing nodular graphite. The ductile iron industry continued to grow at a rate of about 15% in 1973, mainly because of strong demand for ductile cast iron pipe for water transmission systems and for quality castings required by the automotive and farm equipment industries.

The production of lighter and striker flints continued to be a major consumer of mischmetal. Other rare-earth alloys and metals were used in the production of high-temperature alloys and superalloys, and nuclear reactor control rods.

Besides the well-known use of cerium oxide for polishing plate glass, eyeglasses, television tubes, and camera lenses, a major and increasing use, worldwide, of cerium oxide was as a decolorizing agent in refining clear glass. Other rare-earth oxides—praseodymium, erbium, holmium, and neodymium—exhibit strong absorption of light and were used as colorants in glass. Lanthanum oxide increases the refractive quality of camera lenses. The Japanese consumed more than 110 tons of La_2O_3 for this purpose in 1973.

Yttrium oxide and europium oxide were

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[4] American Metal Market. Hitachi Magnetics Starts Samarium Cobalt Production. V. 80, No. 122, June 22, 1973, p. 7.

[5] Metal Progress. Automakers Turn Weight Watchers, Eye HSLA Grades. V. 103, No. 1, January 1973, pp. 32–33.

important phosphor materials in color television tubes. Crystals of yttrium (or gadolinium)-aluminum (or iron) garnet were used as microwave filters and control devices. The garnets, when doped with small quantities of neodymium or erbium, were used as lasers. Some crystals were grown solely for use as gem stones.

Rare-earth oxides and fluorides added to carbon arc electrodes emit a brilliant white light that is necessary for searchlights and for color motion picture photography and projection. This use continues to grow slowly.

High-energy permanent magnets composed of rare earth-cobalt alloys consumed an estimated 3,000 pounds of rare earths, mostly samarium and mischmetal, in 1973. These magnets, which are two to three times more powerful than previous compositions, were used mainly in electric wrist watches and traveling wave tubes. The high strength of these magnets made it possible to eliminate the bearings in aircraft engine tachometers permitting a 30% saving in weight and improving reliability and service life.[6]

STOCKS

Bastnaesite concentrate stocks held by the principal producer and five other chemical processors at yearend declined 52%; monazite concentrate held by the two producers and three processing companies declined almost 47%. Mischmetal stocks held by two principal producers increased 42% during the year and stocks of high-purity metals held by three firms were 37% higher than at the first of the year.

PRICES

Prices for domestic monazite remained stable during the year, whereas prices of foreign-produced monazite rose 5% to 20% because of continued strong demand and reduced production. The average c.i.f. price per metric ton of Australian monazite (minimum 60% REO plus ThO_2), quoted in Metal Bulletin (London), increased from $187 to $206 at mid-year to $200 to $215. The declared value of imported monazite concentrate from Malaysia averaged $123 per short ton in 1973, 23% higher than the previous year. Malaysian xenotime concentrate with a minimum of 25% yttrium oxide content, as quoted in Industrial Minerals (London), remained unchanged at $3 to $5 per pound.

Unleached, leached, and calcined bastnaesite containing 55% to 60%, 68% to 72%, and 85% to 90% REO remained at 30, 35, and 40 cents per pound REO, respectively, f.o.b. Mountain Pass or Nipton, Calif., in 100-pound paper bags or 55-gallon steel drums in truckload or carload lots.

Rare-earth oxide compound prices, in a downtrend since 1965, firmed in 1973; price increases were expected in many items in the coming year, owing to price hikes in concentrates and higher processing costs. Quoted prices per pound f.o.b. plant, for certain rare-earth compounds were as follows: mixed rare-earth oxides, 97% REO, $1.40 under 500 pounds decreasing

Table 1.—Prices of high-purity oxides, salts, and metals in 1973 [1]

(Dollars per pound)

Element	Oxides [2]	Salts [3]	Metals [4]
Cerium	5.00	14.00	50.00
Dysprosium	40.00	30.00	130.00
Erbium	45.00	30.00	160.00
Europium	450.00	250.00	3,000.00
Gadolinium	45.00	28.00	220.00
Holmium	120.00	90.00	300.00
Lanthanum	4.75	14.00	50.00
Lutetium	2,000.00	1,200.00	6,000.00
Neodymium	12.00	14.00	110.00
Praseodymium	32.00	18.00	170.00
Samarium	30.00	18.00	155.00
Terbium	275.00	200.00	725.00
Thulium	1,000.00	600.00	2,600.00
Ytterbium	85.00	75.00	240.00
Yttrium	30.00	16.00	150.00

[1] Research Chemicals, Nucor Corp., f.o.b. Phoenix, Ariz. Other producers may have different prices on some items.
[2] Minimum 99.9% purity, more than 1 pound.
[3] Minimum 99.9% purity, includes chlorides, nitrates, sulfates, oxalates, and acetates.
[4] Minimum 1 pound, ingot form.

[6] Chemical and Engineering News. V. 51, No. 31, July 30, 1973, p. 11.

to $1.10 for lots over 5 tons; chlorides, $0.29; carbonates, $0.83; fluorides, 84% REO, $0.90; and hydrates, $1.30.

Prices for optical-grade ceric oxide in lot sizes of 50 pounds or more delivered in bags or drums, remained at $2 per pound. Quotations on cerium hydrate, 92% CeO_2 of total REO, increased 5 cents per pound to $1.50 whereas 95% to 98% CeO_2, cerium hydrate, decreased 3 cents per pound to $1.55.

Quoted prices on 1-pound ingots in 50- to 100-pound lots of 97% didymium and cerium-free mischmetal remained at $15 and $5, respectively, f.o.b. plant. Mischmetal 99.8%, was quoted at $3.10 per pound, same basis. Ferrosilicon, containing 30% rare-earth metal, was quoted at $1.45 to $1.50 per pound (contained rare-earth metal). Rare earths for magnet use, 99% purity in 10- to 100-pound amounts, as quoted per pound in American Metal Market were as follows: cerium, $19; lanthanum, $28; praseodymium, $62.50; and samarium, $78.

FOREIGN TRADE

According to the sole domestic producer, Molycorp, exports of bastnaesite concentrate were 4,854 tons contained REO, a 94% increase over those of 1972.

Exports of ferrocerium and other pyrophoric alloys to Sweden, Canada, the Netherlands, Australia, and 18 other countries decreased 46%, totaling 109,766 pounds valued at $285,763. The average unit value of $2.60 per pound was 42 cents less than that of 1972.

Exports of compounds and mixtures of rare-earth metals, including yttrium and scandium, increased from 1,514,605 pounds valued at $3,143,895 in 1972 to 4,047,741 pounds valued at $4,592,374 in 1973. The large quantitative increase was due to shipments of 2,462,597 pounds of rare-earth compounds, valued at $654,567, to Austria.

Imports of monazite concentrate increased substantially from those of the previous year. Shipments from Malaysia more than doubled and imports from Thailand resumed for the first time since 1970.

Cerium oxide imports, predominately from West Germany and Austria, totaled 11,716 pounds, valued at $22,826. Imports of cerium chloride, only from Austria, were one-third of the total imports in 1972 amounting to 1,080 pounds, valued at $1,772. Other cerium compounds, n.s.p.f., from France and Austria totaled 16,575 pounds, valued at $34,503, a 161% increase in quantity but only a small increase in unit value.

Imports of rare-earth metals increased sharply in 1973 due to a more than fourfold increase in shipments from the U.S.S.R. (table 2). Imports of ferrocerium and other pyrophoric alloys increased to 38,206 pounds, valued at $126,631, compared with 1972 receipts of 27,870 pounds, valued at $94,347. France supplied 51% of total shipments, valued at $50,614, followed by Japan with 44%, valued at $66,144. Other suppliers were the United Kingdom, Austria, Spain, and Singapore. No mischmetal was imported during 1973.

The tariffs on rare-earth metals and compounds were the same as in 1972. The tariff was 15% ad valorem on cerium oxide and chloride, $0.50 per pound on rare-earth alloys and mischmetal, $0.50 per pound plus 6% ad valorem on ferrocerium and other pyrophoric alloys, and 5% ad valorem on rare-earth metals and yttrium. Rare-earth ores and concentrates remained duty free.

Table 2. U.S. imports for consumption of rare-earth metals
(Including scandium and yttrium)

Country	1971 Quantity (pounds)	1971 Value	1972 Quantity (pounds)	1972 Value	1973 Quantity (pounds)	1973 Value
Germany, West	153	$4,197	--	--	531	$4,322
Japan	25	4,169	2,465	$5,585	--	--
Norway	--	--	22	535	--	--
U.S.S.R.	395	8,689	2,650	51,870	11,446	200,349
United Kingdom	15	4,553	23	7,957	7	5,655
Total	588	21,608	5,160	65,947	11,984	210,326

Table 3.—U.S. imports for consumption of monazite by country
(Short tons and thousand dollars)

Country	1969		1970		1971		1972		1973	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Australia	2,478	300	1,977	251	1,802	219	--	--	--	--
Hong Kong	167	20	--	--	--	--	--	--	--	--
Malaysia	1,561	174	1,307	157	1,571	165	894	89	1,991	244
Thailand	--	--	164	19	--	--	--	--	110	10
Total	4,206	494	3,448	427	3,373	384	894	89	2,101	254
REO content e	2,310	XX	r 1,896	XX	r 1,855	XX	492	XX	1,156	XX

e Estimate. r Revised. XX Not applicable.

WORLD REVIEW

Australia.—Production of monazite decreased 12.6% in 1973 from 1972 because of reduced production and leaner monazite contents of the ore. According to the Rutile and Zircon Development Assoc., Ltd., monazite production by members in short tons by State was as follows:

	1972	1973	% Change
New South Wales	1,604	1,076	−32.9
Queensland	121	64	−47.1
Western Australia	3,056	3,087	+1.0
Total	4,781	4,227	−11.6

Western Titanium, Ltd., a subsidiary of Consolidated Gold Fields Australia, Ltd., reported slightly increased production of monazite, 1,817 tons, and a 60% production increase in xenotime for the year ending June 30, 1973. Ore reserves in the Capel area were re-assessed at 7.8 million tons of heavy minerals made up of 6.4 million tons of proved ore and 1.4 tons of probable ore.[7]

Table 4.—Monazite concentrate: World production by country
(Short tons)

Country [1]	1971	1972	1973 p
Australia	r 4,829	5,537	4,842
Brazil	1,502	2,453	1,606
India	[2] 4,664	4,504	3,858
Malaysia [3]	r 1,622	1,927	2,200
Mauritania e	110	110	110
Nigeria	102	11	6
Sri Lanka	7	e 10	e 10
Thailand	123	188	e 220
United States	W	W	W
Zaire	r 198	251	252
Total	r 13,157	14,991	13,104

e Estimate. p Preliminary. r Revised.
W Withheld to avoid disclosing individual company confidential data.
[1] In addition to the countries listed, Indonesia and North Korea produce monazite, but information is inadequate to make reliable estimates of output levels.
[2] Year beginning April 1 of that stated.
[3] Exports.

Allied Eneabba Pty. Ltd., owned by Allied Minerals N.L. (75%) and DuPont (Australia) Ltd. (25%), planned to construct a 450,000-ton-per-year plant near Eneabba, Western Australia, to process heavy mineral sands for titanium minerals, zircon, and monazite. Full-scale production was scheduled in 1975.[8]

Canada.—Denison Mines, Ltd. resumed recovery of yttrium from uranium waste liquors for the first time since mid-1970. Shipments of yttrium-rich residues were being shipped to Molycorp for processing under a contract that runs to March 1976.

India.—Monazite production by the sole producer, Indian Rare Earths, Ltd. (IRE), decreased 1,388 tons to 3,276 tons in fiscal year 1973 (year ending Mar. 31, 1973). The decreased production was attributed to leaner monazite content in the raw sand and to power shortages at the Manavalakurichi plant. The Alwaye plant of IRE processed 4,350 tons of monazite, producing 4,837 tons of rare-earth chloride, 97 tons of rare-earth fluoride, and 24 tons of REO. Sales of rare-earth compounds declined slightly to 4,815 tons, but the value increased almost 11% to $1,250,000. According to IRE's annual report, the company planned to develop the mineral sand deposits along the Orissa coast. Two Australian firms were preparing a feasibility report on setting up a mineral sand separation plant at Orissa.

[7] Industrial Minerals. Western Ti in 1972: Beneficiation to Proceed. No. 74, November 1973, pp. 28–29.
[8] Metals Sourcebook. V. 10, No. 22, Nov. 19, 1973, p. 3.

Japan.—In 1973 Japanese rare-earth processors consumed increased quantities of bastnaesite concentrate and rare-earth hydrates and reduced amounts of rare-earth chlorides and monazite. Monazite processing continued to diminish because of radioactive pollution problems. Xenotime from Malaysia was the source material for yttrium and heavy rare-earth elements.

Production and demand for rare-earth metals and compounds increased substantially. Imports also increased. Yttrium oxide and mischmetal imports were up 48% to 14 and 11.5 tons, respectively; cerium oxide 54% to 150 tons; and lanthanum oxide 180% to 113 tons.[9] The consumption pattern of rare earths in Japan differs from that of the United States. No rare earths were used in petroleum catalyst manufacture and very little in steel production. Rare earths, consumed by the iron and steel industry, were used mainly in the production of ductile iron. New Japanese steel furnaces are capable of producing very low sulfur steels that do not require rare-earth treatment. Rare-earth consumption in Japan, since 1970, is shown in table 5.

Table 5.—Rare-earth consumption in Japan
(Short tons)

	1970	1971	1972	1973 ᵉ
Y_2O_3: Television phosphors	18	12	22	19
Eu_2O_3: do	1	.8	1.5	1.3
La_2O_3:				
Optical glass	132	66	105	110
Ceramic capacitors	66	44	66	77
CeO_2:				
Decolorizing	66	66	99	110
Polishing	518	540	617	639
Mischmetal:				
Lighter flints	132	132	143	143
Iron and steel	110	110	165	220
RE fluorides:				
Arc carbon	77	77	77	77
Iron and steel	88	72	88	110
Total	1,208	1,119.8	1,383.5	1,506.3

ᵉ Estimated.
Source: Chemical Economy & Engineering Review. Production and Uses of Rare Earths in Japan. V. 5, No. 8, August 1973, pp. 38–44.

Malawi.—Lonrho Ltd. investigated monazite and strontianite occurrences in the carbonatite veins and dikes at Kangankunde Hill. Subject to satisfactory marketing arrangements, Lonrho planned to develop the deposit which has inferred reserves of more than 15,000 tons of monazite.

Norway.—The Metal Extraction Group (Megon) in association with the Atomic Energy Institute planned to construct a 50-ton-per-year plant at Kjeller, Norway, for commercial production of high-purity yttrium oxide. Trial production in a pilot plant, based on imported 60% yttrium concentrate, successfully produced high-purity material.[10]

South Africa, Republic of.—A pilot plant was under construction by the Industrial Development Corp. of South Africa Ltd. and KRC Resources S.A. Pty. Ltd., a subsidiary of King Resources, to evaluate the feasibility of exploiting a rare-earth, titanium, and zirconium heavy mineral deposit in the Richards Bay area of Natal.[11] Late in the year, KRC's 49% share in the deposit was sold to Quebec Iron & Titanium Corp. for $4 million.[12]

TECHNOLOGY

Research on the uses of rare-earth compounds as potential catalysts in automotive emission control received increasing attention in 1973. In controlled laboratory tests, researchers at Bell Laboratories found that rare-earth lead manganites were effective

[9] Japan Metal Journal. Rare Earth Industry in 1973. V. 4, No. 14, Apr. 8, 1974, p. 7.
[10] Mining Journal. V. 282, No. 7220, Jan. 11, 1974, p. 25.
[11] Engineering and Mining Journal. V. 174, No. 2, February 1973, p. 135.
[12] Metals Sourcebook. V. 11, Jan. 28, 1974, p. 4.

in reducing smog-forming nitrogen oxides to harmless nitrogen.[13] Preliminary results indicated these rare-earth compounds were stable under the oxidation-reduction conditions and the high temperatures encountered in exhaust systems and, also, had some tolerance to lead, a serious problem in noble metal converters. Several test samples of rare-earth lead manganites have been submitted to automotive companies for evaluation. Another series of rare-earth catalysts, lanthanum cobalt oxides, were also reported to be effective in dealing with nitrogen oxides.[14]

The Bureau of Mines investigated the catalytic activity of rare-earth oxides for the cathode reaction of a hydrogen-oxygen fuel cell.[15] The oxides of cerium, praseodymium, and europium were significantly more active than the other elements tested.

Preliminary testing of rare-earth β-ketoenolates as antiknock additives to motor fuels indicated they were as effective or better than tetraethyl lead in some applications.[16] The most effective compounds contained cerium and the best compound discovered was cerium (2, 2, 6, 6-tetramethyl-3, 5-heptanedionate)$_4$. An extra benefit of the rare-earth additive was reduced noxious hydrocarbon emission.

Rare-earth phosphate catalysts for the production of synthetic cresol and xylenols made Industrial Research's list of the top 100 new products introduced during 1973. The new catalysts, composed of lanthanum or cerium phosphate, cut operating costs and eliminate the corrosion and pollution problems associated with the presently used caustic hydrolysis process.[17]

A new class of magnetic bubble material, which may greatly increase the storing and processing of computer data, has been discovered. Magnetic bubbles were observed for the first time in thin films of amorphous gadolinium-iron and gadolinium-cobalt. It was claimed that such films not only are easier and less expensive to fabricate than presently used crystalline films but also that they have potentially greater storage capacity estimated at about 1 billion bits per square inch.[18] In another computer development, bismuth-thulium-garnet films were found to contain magnetic bubbles having greater light sensitivity than earlier films. This makes possible optical readout at about 100 times the rate of nonoptical methods.[19]

Epitaxial films of yttrium-iron garnet and gallium-yttrium-iron garnet for use in magnetic bubble domain applications were grown by chemical vapor deposition at reduced pressure using a system which is simpler and offers more direct control over the process than previous systems.[20]

A magnetically controlled switch which can modulate light passing through a thin, single crystal yttrium-gallium-scandium-iron garnet film has been devised.[21] Such a switch may make possible systems where large amounts of information can be transmitted on laser beams.

Bureau of Mines research continued on developing low-cost technology for recovering yttrium and rare earths from apatite in iron ore tailings from New York State. Because an appreciable portion of the yttrium occurs in more soluble hydrated calcium-yttrium silicates in cracks in the apatite grains, more than half of the yttrium present in a concentrate was leachable with dilute H_2SO_4 without dissolving the apatite itself. Both solvent extraction and ion exchange methods were under investigation to extract the yttrium and rare earths from the leach solution.

High purity magnesium-yttrium alloys containing up to 55% yttrium were prepared by electroreduction of Y_2O_3 dissolved in YF_3–LiF bath.[22] A method to electrore-

[13] Voorhoeve, R. J. H., J. P. Remeika, and D. W. Johnson, Jr. Rare-Earth Manganites: Catalysts With Low Ammonia Yield in the Reduction of Nitrogen Oxides. Science, v. 180, No. 4081, Apr. 6, 1973, pp. 62–64.

[14] Chemical and Engineering News. V. 51, No. 13, Mar. 26, 1973, p. 17.

[15] Nicks, L. J., and D. J. MacDonald. Catalytic Activity of Rare-Earth Oxides for the Oxidation of Hydrogen. BuMines RI 7841, 1973, 9 pp.

[16] Chemical and Engineering News. Rare Earths Show Promise as Antiknocks. V. 52, No. 12, Mar. 25, 1974, pp. 27–28.

[17] Institute for Atomic Research, Iowa State University, Ames, Iowa. Catalyst Makes Top 100. Rare Earth Information Center News, v. 8, No. 4, Dec. 1, 1973, p. 4.

[18] Materials Engineering. Magnetic Bubbles Shrink Computer Memories. V. 77, No. 6, June 1973, pp. 27–29.

[19] Institute for Atomic Research, Iowa State University, Ames, Iowa. Bubble Memories. Rare Earth Information Center News, v. 8, No. 4, Dec. 1, 1973, p. 3.

[20] Gentilman, R. L. Chemical Vapor Deposition of Epitaxial Films of Yttrium Iron Garnet and Gallium Substituted Yttrium Iron Garnet and a Thermodynamic Analysis. J. Am. Chem. Soc., v. 56, No. 12, December 1973, pp. 623–627.

[21] Materials Engineering. Communicate Via Light Beams. V. 77, No. 6, June 1973, pp. 27–28.

[22] Aamland, E., D. J. MacDonald, and D. G. Kesterke. Molten Salt Electrowinning of Magnesium-Yttrium Alloys. BuMines RI 7722, 1973, 11 pp.

fine yttrium metal from low-melting yttrium-base alloys was investigated. Metallic impurities in the cathode products were substantially less than in the anode material when yttrium was refined from alloys containing Fe, Ni, and Mn.[23]

A study of thermochemical data on rare-earth reactions in metallurgical processes was completed by the Rare Earth Information Center, Ames, Iowa, under a Molycorp grant. The study contains data on the free energies of formation of various rare-earth oxides and oxysulfides at temperatures up to 2,200° C and data on formation of rare-earth intermetallics with nine other elements.[24]

Research on rare-earth additives in steelmaking continued to be directed toward improving addition techniques. At the 31st Electrical Furnace Conference in December, the relative merits of using rare-earth silicides versus mischmetal additives[25] and rare-earth additions to electric furnaces at the Houston Works of Armco Steel Corp.[26] were discussed. In another paper, the differences in benefits obtained when rare earths are added to steels by various methods were examined on the basis of available thermodynamic information.[27]

The nonmetallic inclusions in rare earth-treated steels were identified.[28] The composition, number, size, shape, and hardness of the inclusions affect the properties obtained.

A high-speed laser welder based on a neodymium-yttrium-aluminum garnet was developed to make up to 100 spotwelds per second on a variety of metals.[29] A sun-pumped, neodymium laser system was under investigation to determine the feasibility of direct optical communications via satellite. The lasing material can be activated by auxiliary lamps when the sun is not visible.[30] Researchers at Battelle Memorial Institute were exploring the use of a very high-powered neodymium glass laser as a means of strengthening steel and other metals by shock hardening. Hardening of the metal is caused by laser induced microstructual defects.[31]

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[23] Fleck, D. C., E. K. Kleespies, and D. G. Kesterke. Purification of Yttrium by Electrorefining. BuMines RI 7710, 1973, 12 pp.

[24] Gschneidner, K. S., Jr., N. Kippenhan, and O. D. McMasters. Thermochemistry of the Rare Earths—Oxides, Oxysulfides and Compounds with B, Sn, Pb, P, As, Sb, Bi, Cu, and Ag. Rare Earth Information Center, Iowa State University, Report IS–RIC–6, 1973, 68 pp.

[25] Luyckx, L., and J. R. Jackman. Current Trends in the Use of Rare Earths in Steelmaking. Rare Earth Industries Inc. Pres. at the 31st Electrical Furnace Conf., Cincinnati, Ohio, Dec. 6, 1973.

[26] Bennett, Howard W., and L. P. Sandell, Jr. Rare Earth Additions to Electric Furnaces for Sulfide Shape Control. J. Metals, v. 26, No. 2, February 1974, pp. 21–24.

[27] Wilson, W. G. Results From Various Methods of Adding Rare-Earths. Molybdenum Corp. of America. Pres. at the 31st Electrical Furnace Conf., Cincinnati, Ohio, Dec. 6, 1973.

[28] Wilson, W. G., and R. G. Wells. Identifying Inclusions in Rare Earth Treated Steels. Metal Prog., v. 104, No. 7, December 1973, pp. 75–77.

[29] Industry Week. V. 178, No. 6, Aug. 6, 1973, p. 25.

[30] Chemical and Engineering News. V. 51, No. 22, May 28, 1973, p. 13.

[31] American Metal Market. Studying the Laser to Strengthen Metal. V. 80, No. 75, Apr. 17, 1973, p. 17.

Rhenium

By Larry J. Alverson [1]

Domestic rhenium production increased 15% and was more than adequate to meet the reduced demand for rhenium, notably in bimetallic platinum-rhenium catalysts. Prices for both metal powder and compounds continued the decline started in 1972. As imports of metal powder and ammonium perrhenate increased significantly during the year, primarily in anticipation of heightened demand for bimetallic catalysts, stocks of rhenium climbed to an all-time high.

Table 1.—Salient rhenium statistics

(Pounds of contained rhenium)

	1970	1971	1972	1973
Mine production [e]	5,900	7,250	6,100	7,000
Consumption [e]	5,100	7,600	[r] 4,800	4,400
Imports (metal and scrap)	210	377	168	1,437
Imports (ammonium perrhenate) [e]	[r] 825	[r] 3,435	[r] 1,845	3,040
Stocks, Dec. 31 [e]	[r] 6,200	[r] 9,700	13,000	20,000

[e] Estimate. [r] Revised.

DOMESTIC PRODUCTION

Production of rhenium, a secondary byproduct material recovered primarily from molybdenite (MoS_2) associated with southwestern United States and Chilean porphyry copper ores, increased in 1973 to an estimated 7,000 pounds of rhenium contained in rhenium salts. Cleveland Refractory Metals (CRM), a subsidiary of Kennecott Copper Corp., was the leading rhenium producer in the United States. CRM processed domestic MoS_2 concentrate from operations of Kennecott and Magma Copper Co., as well as concentrates from Chilean sources, at their Garfield, Utah, roasting facility.

M&R Refractory Metals, Inc., at its Winslow, N.J., plant produced rhenium salts from the MoS_2 recovered at Magma's San Manuel porphyry copper mine for Engelhard Minerals & Chemical Corp. on a contract conversion basis. Shattuck Chemical Co., Denver, Colo., a division of Engelhard Minerals & Chemical Corp., recovered rhenium salts from Arizona molybdenite concentrate. Molybdenum Corp. of America (Molycorp) sold a 50% interest in its new pollution-free hydrometallurgical process for producing molybdenum and rhenium to Cyprus Mines Corp. Cyprus received an undivided interest in the worldwide rights to the process, excluding Japan. The two firms formed a new company, Cymoly Process Corp., to handle the process through construction and/or licensing of processing plants worldwide. Continental Rhenium Corp. closed its commercial pilot plant at Golden, Colo., in the fall of 1973 after operating for about 2 years. Apparently scale-up problems and the soft rhenium market precipitated the shutdown.

Newmont Exploration Ltd., a subsidiary of Newmont Mining Corp., completed installation of a pilot multihearth furnace at its Danbury, Conn., research center. The furnace was used in a research program undertaken to develop a new method to produce salable rhenium from the molybdenite concentrate recovered at Magma's Arizona copper mine.[2]

[1] Industry economist, Division of Ferrous Metals—Mineral Supply.

[2] Newmont Mining Corp. Annual Report, 1973, 32 pp.

CONSUMPTION AND USES

Approximately 75% of the estimated 1973 rhenium metal consumption of 4,400 pounds was used in bimetallic platinum-rhenium catalysts for refining low-lead and no-lead high-octane gasoline. Consumption was down owing mainly to lack of completion of new refineries during the year.

Increases in the compression ratios of automotive engines over the past few years have raised the antiknock requirements of gasoline, resulting in the need for processes to "reform" or improve the octane number of gasoline. One of the most successful of these processes employs a bimetallic platinum-rhenium catalyst. The rhenium inhibits coke formation, making it possible to operate at lower pressures with less frequent catalyst regeneration. Presently, approximately one quarter of all non-Communist countries' bimetallic petroleum reforming catalysts are of the platinum-rhenium variety.

A number of older refineries made conversions from straight platinum to platinum-rhenium catalysts during the year. The Lake Charles, La., refinery of Cities Service Oil Co. made the conversion employing 55,000 pounds of Chevron's Rheniforming catalyst with a rhenium content of about 165 pounds. It was reported that the catalyst functioned well and that the results were very good.

The Los Angeles refinery of Union Oil Co. of California was undergoing a $30 million modification project which included installation of a catalytic reformer employing Universal Oil Products Co.'s R–16 bemetallic platinum-rhenium catalyst for the production of high-octane, lead-free gasoline. Completion was scheduled for sometime in mid-1974.

Standard Oil Co. of California planned to add two large hydrosulfurization units and a catalytic reforming unit to their Richmond, Calif., refinery. Plans called for a 25,000-barrel-per-day Rheniformer aimed at boosting the plant's capacity to produce low-lead gasolines. The project was scheduled for completion in 1976.

The remaining 25% of estimated domestic rhenium consumption was for high-temperature thermocouples, electronic devices, X-ray tubes, electrical contacts, vacuum tube and flashbulb filaments, heating elements, and electromagnets.

CRM sold its X-ray target fabrication facilities to General Electric Co. and sold the rhenium sheet, bar, and tubing fabrication unit to H. Cross of Weehawken, N.J. CRM retained its production facilities for ammonium perrhenate, perrhenic acid, and rhenium metal powder.

Pure rhenium was utilized in filaments for mass spectrographs because it is less affected by many inpurities. Also, if any oxide film forms on the filaments, the conductive rhenium oxide does not increase the filament resistance which would probably lead to overheating and burnouts.

Engelhard Minerals & Chemical Corp. continued to market tungsten-3% rhenium versus tungsten-25% rhenium thermocouples. This couple can accurately measure temperatures up to 2,400° C and is suitable for use in vacuum, hydrogen, and clean inert gases such as argon and helium.

A publication dealing extensively with rhenium was made available during the year by Roskill Information Services, Ltd., of London. It covers information on geology, reserves, producing countries, consumption, uses, prices, and general and specific trends.[3]

A Bureau of Mines publication was issued during the year that discusses rhenium and other metals, primarily from an economic point of view, as byproducts of the copper industry.[4]

PRICES

Prices paid for rhenium metal powder during the year ranged from about $900 to $675 per pound, depending on quantity, decreasing toward the latter by yearend. Prices for perrhenic acid, a starting material used in catalytic applications, ranged from about $875 to $625 per pound, depending on quantity, trending toward the latter in second half of the year. These

[3] Roskill Information Services Ltd. (London). The Economics of Rhenium. January 1973, 43 pp.

[4] Petrick, A., Jr., H. J. Bennett, K. E. Starch, and R. C. Weisner. The Economics of Byproducts Metals (In Two Parts). 1. Copper System. BuMines IC 8569, 1973, 105 pp.

price decreases reflected the soft nature of the rhenium market which was due principally to the lack of new refineries that would utilize bimetallic platinum-rhenium catalysts.

FOREIGN TRADE

Imports for consumption of unwrought rhenium metal during 1973 increased greatly over those of 1972 and totaled 1,437 pounds valued at $1,004,676. These imports, all of which represented rhenium metal powder, came from West Germany (78%), the Netherlands (15%), and Belgium-Luxembourg (7%). There were no imports of scrap or wrought rhenium metal during the year. Unwrought rhenium metal imports are believed to have been recovered from byproduct molybdenite obtained from porphyry copper ore mined in Chile and Peru. The average price of the metal imports, excluding U.S. duty, was $699 per pound, and ranged from $677 per pound (Belgium-Luxembourg) to $701 per pound (West Germany).

Imports of ammonium perrhenate (NH_4ReO_4) salts, all from Sweden and West Germany, nearly doubled during the year to an estimated 3,040 pounds of contained rhenium valued at $3,829,000. This material was imported under the basket classification "Ammonium compounds, not specifically provided for" (TSUS 417.44).

The main reasons for increased imports in the face of decreased consumption were the fulfilling of existing contracts and the stockpiling of rhenium in anticipation of increased demand from the spate of new refineries that were expected to come onstream in 1975–76. Also, as a result of the foregoing, stocks of rhenium were at an alltime high.

The import duty on rhenium metal from non-Communist countries remained at the January 1, 1972 rate of 5% ad valorem for unwrought rhenium metal and scrap, and 9% ad valorem for wrought rhenium metal. The import duty on wrought and unwrought rhenium metal from Communist Bloc countries also remained unchanged at 45% and 25% ad valorem, respectively. The duty on imports of ammonium perrhenate from Communist

Table 2.—U.S. imports for consumption of rhenium (including scrap), by country

(Gross weight)

Country	1970		1971		1972		1973	
	Quantity (pounds)	Value	Quantity (pounds)	Value	Quantity (pounds)	Value	Quantity (pounds)	Value
Belgium-Luxembourg	--	--	220	$262,278	--	--	110	$74,500
France	58	$53,789	45	49,770	25	$23,796	--	--
Germany, West	79	34,373	110	140,000	143	101,955	1,116	782,497
Netherlands	--	--	--	--	--	--	211	147,679
United Kingdom	--	--	2	794	--	--	--	--
U.S.S.R.	73	23,467	--	--	--	--	--	--
Total	210	111,629	377	452,842	168	125,751	1,437	1,004,676

Table 3.—Estimated imports for consumption of ammonium perrhenate by country[r 1]

(Rhenium content)

Country	1970		1971		1972		1973	
	Pounds	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)
Germany, West	115	$115	1,395	$1,545	845	$1,054	1,450	$1,913
Sweden	710	659	2,040	2,202	1,000	1,189	1,590	1,916
Total	825	774	3,435	3,747	1,845	2,243	3,040	3,829

[r] Revised.
[1] Figures are derived from the basket category "Ammonium compounds not specifically provided for" (TSUS 417.44).

and non-Communist countries was 25% and 4% ad valorem, respectively. The import duty on waste and scrap was suspended until June 30, 1975.

WORLD REVIEW

Australia.—Exploration of a copper-molybdenum deposit at Mt. Mulgine in Western Australia by Minefields Exploration N.L. was reported in 1970 to have produced core samples containing rhenium in "relatively high" concentrations. It was announced that the company proposed to spend $300,000 by the end of 1973, to investigate the deposit.

Canada.—The sole source of Canadian rhenium production was copper-molybdenum ore from the Island Copper Mine of Utah International, Inc., at Port Hardy, British Columbia. The ore occurs mainly in altered volcanics, and in this respect, differs from the porphyry copper deposits of the United States and Chile. Molybdenite concentrate was first produced in 1972 when shipments were 400 tons and contained about 1,200 pounds of rhenium. In 1973 shipments were about 1,200 tons containing 3,200 pounds of rhenium. To date, molybdenite purchasers have either paid for the contained rhenium or recovered the rhenium on a toll basis and returned it for direct sale by Utah International, Inc.

The rhenium content of a molybdenite concentrate averaging 95.9% MoS_2 obtained from Brenda Mines Ltd. in south-central British Columbia was found to be less than 10 parts per million (ppm) rhenium; too low to warrant economic recovery.[5]

Chile.—Concomitant to expansion of copper production in Chile, byproduct molybdenite and rhenium output will be greatly increased over the next 2 years. Corporación del Cobre (CODELCO) was constructing a new 30,000,000 pound per year molybdenum concentrate plant at Chuquicamata. A new molybdenum concentrating plant was also being constructed at the Río Blanco mine of Companía Minera Andina, S.A. The substantial rhenium content of the concentrate of these two plants will also be recovered. By 1976, Chile should have a yearly rhenium capacity of 11,000 pounds, thus potentially making her one of the world's leading rhenium producers.[6]

Researchers at the universities of Concepción and Antofagasta were attempting to develop techniques for the recovery of rhenium from copper ore. Experts calculate that commercial extraction of rhenium could earn Chile an extra $2 per ton of copper produced. At present no rhenium is recovered from the copper side of the circuit, but is recovered from the molybdenum circuit.

Detailed studies of the newly discovered porphyry copper ore body, San Jose del Abra (El Abra), about 25 miles north of Chuquicamata, have proven 25,000,000 tons of 0.80% to 1.0% soluble oxide copper and indicated 400,000,000 tons of 0.90% sulfide copper. High rhenium values have been discovered in the deposit now under consideration for development by CODELCO. A 16-mile road was being opened to connect El Abra, at 12,500 feet, with Chuquicamata.[7]

Germany, East.—Rhenium is believed to be produced at the Hettstedt plant of VVB Mansfeld where it is extracted from the copper-bearing slates of the Mansfeld mines. Potassium perrhenate is recovered from which rhenium metal is produced.

U.S.S.R.—Rhenium was being recovered in substantial quantities from MoS_2 concentrates obtained from porphyry copper deposits in the U.S.S.R. The main rhenium production was at the Balkhash copper smelter in Kazakhstan, where an estimated 2,500 pounds per year of rhenium was recovered from all rhenium-bearing materials in different operations. Various reports indicated that the large Dzhezkazgan ore body contained important rhenium values, not necessarily associated with molybde-

[5] Johnson, A. E. Mineralogical and Textural Study of the Copper-Molybdenum Deposit of Brenda Mines Limited, South-Central British Columbia. Miner. Sci. Div., Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada, IC 302, 1973, 8 pp.

[6] Intermet Bulletin. Chile: From Agony to a New Challenge. V. 3, No. 3, January 1974, pp. 8–15.

[7] World Mining. Chile's Copper Now. V. 26, No. 11, October 1973, pp. 36–41.

Metals Week. V. 44, No. 51, Dec. 17, 1973, p. 10.

The Northern Miner. World's Largest Copper Reserve Being Developed in Chile. V. 59, No. 26, Sept. 13, 1973, pp. 4–5.

num, and that recovery of these values were planned in the future.[8]

A deposit of molybdenite in Transbaikalia was reported to contain economically recoverable quantities of rhenium. A batch of 49 samples was analyzed and shown to contain 21 to 165 ppm of rhenium, the average being 82 ppm. There were other minerals in the deposit, but the rhenium occurred only in the molybdenite.

Yugoslavia.—Ore of the Majdanpek copper mine contains minor amounts of molybdenum and rhenium, however, they apparently exist in quantities currently insufficient for economical recovery.

Zaire, Republic of.—Copper concentrate from the Katanga copper mines, which contains small amounts of rhenium, was exported to Belgium where the contained rhenium was recovered by Métallurgie Hoboken-Overpelt S.A./N.V. Some of this material was then exported to the United States (110 pounds in 1973) in the form of rhenium metal powder.

TECHNOLOGY

The Bureau of Mines pilot plant studies on recovery of molybdenum and rhenium from low-grade molybdenite concentrates were substantially completed during the year. Over-all molybdenum-rhenium recovery using a solvent extraction-carbon absorption system was 98%. Corresponding power consumption ranged between 10 and 13.7 kilowatt hours per pound of molybdenum extracted. A commercial producer of molybdenum and rhenium continued pilot-scale studies of the process.

The Bureau of Mines published the results of a study on extraction of molybdenum and rhenium from low-grade molybdenite concentrates by electrooxidation.[9]

The Bureau continued its research to improve the selectivity and recovery of molybdenum and rhenium during froth flotation of copper sulfide concentrate from disseminated ores.

A study was undertaken to determine the effects of small rhenium additions on low-temperature ductility of molybdenum and to characterize the mechnical properties of dilute molybdenum-rhenium (Mo-Re) alloys. High-purity Mo-Re alloys had ductile-brittle transition temperatures much lower than those for unalloyed molybdenum in both bend and tensile tests and in both recrystallized and worked conditions. At 1,315° C, an alloy of molybdenum with 5.9% rhenium had a 70% greater tensile strength and a 100% greater creep strength than did the unalloyed molybdenum.[10]

A study was conducted on doped tungsten-rhenium alloys which identified the source of the unique interlocked elongated grains responsible for the high-temperature sag resistance of these alloys as bubbles formed by volatilization of potassium during sintering. By pinning grain boundaries, these bubbles raised the recrystallization temperature (from 1,300° to 2,100° C), and their distribution into rows by annealing controlled the recrystallized grain morphology.[11]

In 1970 it was discovered that copper produced from mine water by cementation with iron, contains small but significant quantities of rhenium. It was found that 90% of the contained rhenium could be selectively leached from the precipitate copper and recovered as purified oxide. A process for production of rhenium from the copper was proven on a semicommercial scale (equivalent to about 350 pounds of rhenium oxide per year).[12]

A new method of copper-molybdenum concentration from low-grade porphyry ore (0.005% to 0.006% Mo) was put into practice at the Balkhash dressing plant at Kazakhstan, U.S.S.R. Steam is supplied to each flotation cell tangentially to the impeller, and the temperature is automatically held at the required value. Sodium sulfide (3.7 to 6.6 pounds per ton) is then fed to the cleaning cells. The results of

[8] Sutulov, Alexander. Mineral Resources and the Economy of the U.S.S.R. McGraw-Hill Inc., New York, 1973, 192 pp.

[9] Lindstrom, R. E., and B. J. Scheiner. Extraction of Molybdenum and Rhenium From Concentrates by Electrooxidation. BuMines RI 7802, 1973, 12 pp.

[10] Klopp, W. D., and W. R. Witzke. Mechanical Properties of Electron-Beam-Melted Molybdenum and Dilute Mo-Re Alloys. Met. Trans, v. 4, No. 8, August 1973, pp. 2006–2008.

[11] Simpson, R. P., G. J. Dooley, III, and T. W. Haas. Study of Grain Boundary Fracture Surfaces in Doped Tungsten-Rhenium Alloys. Met. Trans., v. 5, No. 3, March 1974, pp. 585–591.

[12] Amman, P. R., and T. A. Loose. Recovery of Rhenium from Precipitate Copper. Pres. at Ann. Meeting of AIME, Dallas, Tex., Feb. 25, 1974.

the process guarantee average molybdenum recovery in the separation cycle of 93% and a 2.6-fold increase in rhenium content in tailings.[13]

The Continental Ore Corp. received a patent for recovery of rhenium and molybdenum from MoS_2 concentrate. The process comprises preheating finely divided MoS_2 concentrate and passing it downward through a vertical reaction zone countercurrently to an upflowing stream of high-temperature oxygen, oxygen enriched air, or oxygen-sulfur dioxide mixture. The rhenium values are collected outside the first oxidation zone and dissolved in water. The process is attractive from a pollution control standpoint because byproduct SO_2, ordinarily released to the atmosphere, is produced in the exhaust gases in concentrations high enough to make its recovery economically feasible.[14]

Molycorp was issued a patent on a solvent extraction process for recovering molybdenum and rhenium from molybdenite. The process involves contacting the solution with an alkyl phosphonate to extract rhenium, organic acids, and other impurities, followed by contacting the extracted solution with an organophosphoric acid and recovering molybdenum and rhenium values by conventional means. The process is applicable to recovery of metal values from leach solutions having a sulfuric acid content of up to 600 grams per liter resulting from nitric acid-oxidation leach of molybdenite.[15]

A patent was issued to Newmont Exploration Ltd., a subsidiary of Newmont Mining Corp., for the recovery of rhenium from molybdenite. The conventional oxidative roasting of MoS_2 concentrate was modified to reduce the dilution of the oxidized rhenium vapor species in the gaseous effluent by substituting a mixture of oxygen and water for air in the roasting reaction, the water serving to maintain roasting zone temperature at about 600° C.[16]

A number of patents dealing with catalytic cracking, hydrocracking, catalytic reforming, and hydrocarbon conversion, employing rhenium in combination with other metals such as gallium, selenium, tungsten, germanium, and iridium in bimetallic, trimetallic and tetrametallic combinations, were issued to various oil and chemical companies.[17]

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[13] World Mining. How Russians Increase Cu-Mo Recoveries at Balkhash. V. 26, No. 5, May 1973, pp. 41–42.

[14] Lake, J. L., J. E. Litz, R. B. Coleman, M. Goldenberg, M. Vojkovie (assigned to Continental Ore Corp., New York). Recovery of Rhenium and Molybdenum Values From Molybdenite Concentrates. U.S. Pat. 3,770,414, Nov. 6, 1973.

[15] Peterson, H. D. (assigned to Molybdenum Corp. of America, Denver, Colo.). Solvent Extraction Process for the Recovery of Molybdenum and Rhenium From Molybdenite. U.S. Pat. 3,751,555, Aug. 7, 1973.

[16] Lapat, P. E., W. C. Hellyer (assigned to Newmont Exploration Ltd., Danbury, Conn.). Recovery of Rhenium From Molybdenite. U.S. Pat. 3,798,306, Mar. 19, 1974.

[17] Bertolacini, R. J., D. K. Kim (assigned to Standard Oil Co., Chicago, Ill.). Reforming Petroleum Hydrocarbons With Catalysts Promoted With Gallium and Rhenium. U.S. Pat. 3,772,184, Nov. 13, 1973.

Hayes, J. C. (assigned to Universal Oil Products Co., Des Plaines, Ill.). Hydrocarbon Conversion With a Trimetallic Catalytic Composite. U.S. Pat. 3,775,301, Nov. 27, 1973.

Head, B. D., G. R. Martin (assigned to the Dow Chemical Co., Midland, Mich.). Process for Hydrocarbon Cracking Using a Tungsten-Rhenium Catalyst. U.S. Pat. 3,773,656, Nov. 20, 1973.

Mahoney, J. A., T. D. Nevitt (assigned to Standard Oil Co., Chicago, Ill.). Method for Starting Up a Reforming Process Employing a Catalyst Containing a Group VIII Metal, Rhenium, and Selenium. U.S. Pat. 3,793,183, Feb. 19, 1974.

Rai, C. (assigned to Cities Services Oil Co., Tulsa, Okla.). Reforming Catalyst. U.S. Pat. 3,776,860, Dec. 4, 1973.

Rausch, R. E. (assigned to Universal Oil Products Co., Des Plaines, Ill.). Tetrametallic Hydrocarbon Conversion Catalyst and Uses Thereof. U.S. Pat. 3,790,473, Feb. 5, 1974.

Schrepfer, M. W. (assigned to Universal Oil Products Co., Des Plaines, Ill.). Catalytic Reforming of a Relatively Lean Charge Stock in a Two-Step Process. U.S. Pat. 3,785,961, Jan. 15, 1974.

Salt

By Charles L. Klingman [1]

The quantity of salt used and sold in the United States has not shown any significant movement since 1969. The 1973 figure was 99% of the 1969 quantity. Salt production in 1973 was 95% of the peak production in 1970. Between 1965 and 1970, salt had a growth rate of about 6% per year, so the 1969–73 plateau looked disappointing by comparison.

The largest single factor in the declining salt usage of 1973 was the small requirement for deicing. Rock salt, specified for highway deicing, experienced a 34.6% decline, more than 3 million tons, in the amount sold or used. Stockpiles of salt intended for highway use were large at yearend.

Another factor significantly influencing salt consumption was the large swing from synthetic (Solvay) soda ash manufacture, a process requiring salt as a raw material, to natural soda ash derived from the mineral trona. There was an 18% decline in salt used to make synthetic soda ash in 1973 compared with that of 1972; a reduction equivalent to more than 1 million tons of salt. The future outlook for salt in making soda ash is even lower than it was in 1973.

A third influencing factor on 1973 salt production was a shortage of fuel. Evaporated salt made in vacuum pans is the most energy-intensive of the salt-producing processes. In fact, the reduction in vacuum-pan salt production was attributed to this energy requirement. However, this loss was offset by greater production of solar salt and open-pan (grainer) salt.

Net imports of salt (imports minus exports) amounted to 2,578,000 tons or 6% of the salt sold and used in the United States in 1973. These figures were almost identical to the net import figures of 1972.

The average unit value of various types of salt, as assigned by the manufacturers when ready for sale, showed a 9% increase in 1973 over that of 1972 for both evaporated salt and brine. Rock salt showed less than a 1% increase in value.

[1] Physical scientist, Division of Nonmetallic Minerals—Mineral Supply.

Table 1.–Salient salt statistics

(Thousand short tons and thousand dollars)

	1969	1970	1971	1972	1973
United States:					
Production [1]	NA	46,764	44,700	44,010	44,298
Sold or used by producers [1]	44,245	45,896	44,077	45,022	43,910
Value	287,680	304,759	303,687	296,772	306,103
Exports	716	423	670	869	609
Value	4,486	3,657	4,182	5,544	4,400
Imports for consumption	3,302	3,536	3,855	3,463	3,187
Value	11,990	13,329	14,429	11,979	12,457
Consumption, apparent	46,831	49,009	47,262	47,616	46,488
World: Production	150,495	161,081	r 159,107	r 162,941	165,526

r Revised. NA Not available.
[1] Excluding Puerto Rico; 32,000 short tons (1969 and 1970), 28,500 short tons (1971), 29,000 short tons (1972 and 1973).

DOMESTIC PRODUCTION

Sixteen States recorded production of salt in 1973. Two of the States, Louisiana and Texas, accounted for 54% of the salt sold or used, and three other States, New York, Michigan, and Ohio brought the total up to 87%. Eight of the States, accounting for 96% of the national total, sold or used more than 1 million tons each of salt.

There were 52 salt companies operating 95 plants in the United States and Puerto Rico. Ten of these companies produced over 1 million tons each and accounted for 82% of the U.S. salt production. Eighteen other companies, producing between 100,000 and 1 million tons each, brought the total up to 99% of the U.S. output. Twenty-four other companies whose individual production was under 100,000 tons per year supplied the remaining 1% of the salt output.

A secondary shaft at the Cargill, Inc., salt mine on Belle Isle, La., caved in March 1973,[2] shutting down production for nearly 1 year. The cost of repairing the damage was estimated to be enormous and full operations were not scheduled to resume until mid-1976.

PPG Industries, Inc., closed its synthetic soda ash plant at Barberton, Ohio, in April 1973. This plant was capable of consuming up to 1 million tons of salt per year.

The Leslie Salt Co. announced in December 1973 that it would close its large salt plant in Redwood City, Calif., by the end of 1976. Facilities at Redwood City will be shifted to another Leslie plant at Newark, Calif.

Great Salt Lake Minerals & Chemicals Corp. announced at midyear that it planned to expand operations and that the expansion included facilities for washing and drying 150,000 tons of high quality salt per year.

Cargill, Inc., purchased two salt companies during the year. They were the Barton Salt Co. near Hutchinson, Kan., and the Cayuga Rock Salt Co., Inc., near South Lansing, N.Y. The Cargill mine at South Lansing, N.Y., was modernized with a new underground electrical system and extensions to the main belt conveyor.

Domtar Chemicals, Ltd., of Montreal, Canada, purchased the Carey Salt Co. operation at Louisa (St. Mary Parish), La., in mid-1973.

The International Salt Co. salt mine at Retsof, N.Y., completely replaced its underground railcar hauling complex with 4 miles of conveyor belts.[3] The new conveyor belt installation costing $3.1 million was projected to be amortized in 3 to 5 years. The system was claimed to reduce labor costs 19%, increase production 21%, and reduce maintenance costs 82% in addition to saving $3,000 per month in electricity costs.

At international's Cleveland, Ohio mine, feeder-breakers and a 48-inch-belt conveyor were installed in place of loading machines and trucks to reduce costs from $0.175 per ton to $0.087 per ton.[4]

[2] Engineering and Mining Journal. Large Crater Forces Closure of Belle Isle salt mine. V. 174, No. 5, May 1973, p. 32.
[3] Pit and Quarry. Mine Haulage Conversion Boosts Output, Cuts Costs. V. 66, No. 10, April 1974, pp. 95–99, 114.
[4] Mining Magazine. Feeder-Breaker for Salt Mine. V. 130, No. 1, January 1974, p. 49.

Table 2.—Salt sold or used by producers in the United States, by method of recovery

(Thousand short tons and thousand dollars)

Recovery method	1972 Quantity	1972 Value	1973 Quantity	1973 Value
Evaporated:				
Bulk:				
Open pans or grainers	388	13,225	525	16,546
Vacuum pans	3,287	85,081	2,984	87,489
Solar	1,799	15,115	1,924	17,299
Pressed blocks	376	10,927	451	14,508
Total [1]	5,850	124,348	5,884	135,843
Rock:				
Bulk	14,369	88,903	12,275	75,993
Pressed blocks	66	2,138	72	2,551
Total [1]	14,434	91,041	12,347	78,544
Salt in brine (sold or used as such)	24,737	81,383	25,680	91,717
Grand total [1]	45,022	296,772	43,910	306,103

[1] Data may not add to totals shown because of independent rounding.

Table 3.—Salt sold or used by producers in the United States

(Thousand short tons and thousand dollars)

State	1972 Quantity	1972 Value	1973 Quantity	1973 Value
California	1,621	14,860	1,507	15,533
Kansas [1]	1,369	20,562	1,397	23,460
Louisiana	13,514	67,464	13,152	66,211
Michigan	4,358	50,761	4,818	53,732
New York	5,604	43,866	5,202	42,364
Ohio	6,147	47,710	4,657	41,643
Oklahoma	W	W	5	36
Texas	9,744	36,544	10,354	45,350
Utah	660	4,955	717	6,913
West Virginia	1,232	5,963	1,217	6,082
Other States [2]	771	4,087	885	4,778
Total [3]	45,022	296,772	43,910	306,103
Puerto Rico	29	580	29	580

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Quantity and value of brine included with "Other States."
[2] Includes Alabama, Colorado, Hawaii, Kansas (brine only), Nevada, New Mexico, North Dakota, and States indicated by symbol W.
[3] Data may not add to totals shown because of independent rounding.

Table 4.—Evaporated salt sold or used by producers in the United States

(Thousand short tons and thousand dollars)

State	1972 Quantity	1972 Value	1973 Quantity	1973 Value
California	1,355	13,980	1,246	14,594
Kansas	723	17,207	782	19,914
Louisiana	269	8,840	285	9,976
Michigan	1,169	32,562	1,129	33,359
New York	600	18,015	632	19,353
Ohio	806	22,174	777	W
Oklahoma	W	W	5	36
Other States [1]	930	11,571	1,028	38,612
Total	5,850	124,348	5,884	[2] 135,843
Puerto Rico	29	580	29	580

W Withheld to avoid disclosing individual company confidential data; included in "Other States."
[1] Includes Hawaii, Nevada, New Mexico, North Dakota, Texas, Utah, and States indicated by symbol W.
[2] Data does not add to total shown because of independent rounding.

Table 5.—Rock salt sold by producers in the United States

(Thousand short tons and thousand dollars)

Year	Quantity	Value
1969	13,397	86,452
1970	14,170	95,291
1971	13,700	89,321
1972	14,434	91,041
1973	12,347	78,544

Table 6.—Pressed-salt blocks sold by original producers of salt in the United States

(Thousand short tons and thousand dollars)

Year	From evaporated salt Quantity	From evaporated salt Value	From rock salt Quantity	From rock salt Value	Total Quantity	Total Value
1969	369	9,622	83	2,352	452	11,974
1970	368	10,085	79	2,269	447 [1]	12,353
1971	367	10,532	87	2,095	454	12,627
1972	376	10,927	66	2,138	442	13,065
1973	451	14,508	72	2,551	523	17,059

[1] Data does not add to total shown because of independent rounding.

CONSUMPTION AND USES

Of the total salt consumed in 1973, 59% was distributed as brine, 27% as rock salt, and 14% as evaporated salt. The production of caustic soda and chlorine required 51% of the total salt output, up from 45% in 1972. The amount of salt going into the manufacture of synthetic soda ash, was 11% of the output compared with 13% in 1972. Other miscellaneous chemicals required 3% of the salt, making the total chemical requirements equal to 65% of the salt used and sold in 1973. This was a significant increase from the 60% required for chemical manufacture in 1972.

The salt sold to various governmental agencies, presumed to be used primarily for highway deicing, was down to 14% of the total from 21% in 1972, more than offsetting the gain in chemicals manufacture. Other uses required about the same amount of salt in 1973 as was needed in previous years.

It will be noted that the consumption totals in tables 7 and 8 differ slightly from those in tables 1 through 5. These differences reflect the point at which consumption is reported by salt companies in various sections of the annual salt survey. The Bureau of Mines made no attempt to reconcile these differences, but reported them as received.

Table 7.—Distribution of salt sold or used by producers in the United States, by use

(Thousand short tons)

Consumer or use	1972				1973			
	Evaporated	Rock	Brine	Total [1]	Evaporated	Rock	Brine	Total [1]
Chlorine	302	2,706	17,718	20,726	W	W	20,052	22,598
Soda ash	W	W	5,786	5,791	(2)	(2)	4,776	4,776
Soap (including determent)	22	5	(2)	27 }	W	850	W	1,402
All other chemicals	440	479	117	1,036 }				
Textile and dyeing	132	75	--	207	123	78	--	201
Meatpackers, tanners, and casing manufacturers	266	353	--	619	247	330	--	577
Fishing	42	4	--	45	(3)	(3)	(3)	(3)
Dairy	56	24	--	80	58	3	--	61
Canning	160	68	(2)	228	169	68	(2)	238
Baking	110	7	--	117	114	8	--	122
Flour processors (including cereal)	70	12	(2)	83	75	10	(2)	85
Other food processing	483	37	(2)	520	536	W	W	576
Ice manufacturers and cold storage companies	1	2	--	3	(3)	(3)	(3)	(3)
Feed dealers	933	453	(2)	1,386	880	490	(2)	1,370
Feed mixers	354	223	--	577	427	287	--	713
Metals	W	175	W	227	W	177	W	228
Ceramics (including glass)	4	3	--	7	(4)	(4)	(4)	(4)
Rubber	86	W	W	173	W	W	W	166
Oil	47	62	93	202	52	61	101	215
Paper and pulp	W	125	W	201	W	120	W	209
Water softener manufacturers and service companies	350	W	W	698	338	W	W	687
Grocery stores	802	456	(2)	1,258	881	411	(2)	1,292
Railroads, bus, and transit companies	1	4	--	6	(4)	(4)	(4)	(4)
Highway use	464	8,787	4	9,255	327	5,751	(2)	6,079
U.S. Government	26	65	(2)	91	33	68	(2)	102
Miscellaneous	705	555	809	2,069	908	2,632	257	--
Undistributed [5]	70	364	137	--	737	680	810	2,227
Total [1]	[6] 5,926	[6] 15,044	[6] 24,664	[7] 45,634	[6] 5,905	[6] 12,024	[6] 25,996	[7] 43,924

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Data may not add to totals shown because of independent rounding.
[2] Less than ½ unit, included with "Undistributed."
[3] Included with "Other food processing."
[4] Included with "Miscellaneous."
[5] Includes withheld figures and some exports and consumption in overseas areas administered by the United States.
[6] Differs from totals shown in tables 2, 4, and 5 because of changes in inventory.
[7] Differs from totals shown in tables 1, 2, and 3 because of changes in inventory.

Table 8.—Distribution (shipments) of evaporated and rock salt in the United States, by destination

(Thousand short tons)

Destination	1972		1973	
	Evaporated	Rock	Evaporated	Rock
Alabama	50	407	55	320
Alaska	W	--	W	W
Arizona	36	1	33	4
Arkansas	21	97	21	90
California	915	146	986	W
Colorado	113	46	90	W
Connecticut	17	W	17	W
Delaware	6	W	6	W
District of Columbia	4	W	3	W
Florida	41	124	51	137
Georgia	61	263	62	260
Hawaii	W	--	W	--
Idaho	57	1	70	W
Illinois	353	1,304	365	1,046
Indiana	159	555	165	459
Iowa	200	340	196	329
Kansas	89	189	94	179
Kentucky	48	517	49	505
Louisiana	52	449	52	628
Maine	9	W	10	W
Maryland	44	W	42	31
Massachusetts	77	W	42	320
Michigan	204	W	206	W
Minnesota	150	307	136	290
Mississippi	19	114	22	103
Missouri	111	356	113	314
Montana	58	1	74	1
Nebraska	119	93	127	95
Nevada	31	W	37	W
New Hampshire	W	W	W	77
New Jersey	157	408	160	W
New Mexico	51	45	61	47
New York	326	2,021	322	1,192
North Carolina	125	148	122	155
North Dakota	35	W	W	5
Ohio	371	1,300	401	1,035
Oklahoma	41	66	54	66
Oregon	41	W	60	W
Pennsylvania	186	996	190	565
Rhode Island	15	W	15	W
South Carolina	40	21	45	19
South Dakota	56	28	60	32
Tennessee	122	557	124	539
Texas	322	237	198	255
Utah	108	W	231	W
Vermont	6	W	7	W
Virginia	99	108	98	W
Washington	120	(1)	116	(1)
West Virginia	23	136	23	140
Wisconsin	178	716	191	483
Wyoming	29	3	25	3
Other [2]	431	2,945	279	2,301
Total [3] [4]	5,926	15,044	5,905	12,024

W Withheld to avoid disclosing individual company confidential data; included with "Other."
[1] Less than ½ unit.
[2] Includes shipments to overseas areas administered by the United States, Puerto Rico, exports, some shipments to unspecified destinations, and States indicated by symbol W.
[3] Data may not add to totals shown because of independent rounding.
[4] Differs from totals in tables 2, 4, and 5 because of changes in inventory.

The use of salt for deicing and in many other industrial processes came under scrutiny in 1973. For example, its use as a deicing agent on highways and walks, a major salt usage, was attacked because it promoted corrosion of automobile bodies, deteriorated concrete, and either inhibited or prevented plant growth along the salted areas. Objections to salt deicing were tempered by applying a "diluted" salt-sand mixture instead. This mixture not only melted the snow, but the sand embedded itself immediately upon initial melting in the remaining ice forming a continuous skid preventive surface.

The effluent discharged from synthetic (Solvay) soda ash plants into freshwater streams was also contested. These effluents, high in salt and calcium chloride, supposedly affected both the potability of the water and plant growth along the banks. Legislation passed to regulate these effluents were in some instances so stringent that several soda ash plants shut down because of inability to meet the new standards.

The tanning of cattle hides utilizes salt brine to cure and clean the hides, and most of the spent brine is disposed of through sewage treatment plants. Salt is generally not removed by normal sewage treatment and eventually is discharged into freshwater lakes or streams. In 1972, an estimated 260,000 tons of salt was used to preserve cattle hides and two-thirds of this amount was discharged into fresh waters.[5] This condition could be alleviated by either eliminating salt curing or by partially tanning the hides to produce a "blue, chrome-tanned leather." Regardless, either of the proposed methods, which have not been evaluated, would require changes in processing and marketing of hides and would have an adverse impact on salt consumption.

[5] Renderer. Major changes in Store for Tanners. April 1974, pp. 17, 27.

PRICES

Salt prices quoted in Chemical Marketing Reporter were unchanged during 1973 because of Government price regulation. The prices per 100 pounds were as follows:

	1973
Salt, evaporated, common, in bags, carlots, or truck lots, works	$1.43
Salt, chemical-grade, same basis	1.54
Salt, rock, medium, coarse, same basis	.97
Salt, rock, extra coarse, same basis	1.02

The average value of the different classes of salt per ton, as assigned by the salt producers, was as follows:

	1972	1973
Evaporated salt	$21.26	$23.09
Rock salt	6.31	6.36
Salt in brine	3.29	3.57

FOREIGN TRADE

In 1973, exports of salt amounted to 609,000 tons or 1% of salt consumption. This was 30% less than exports in 1972 and 9% less than those of 1971. Over 90% of exports went to Canada, and the only other country receiving more than 1% was Japan at 4%.

Total salt imports into the United States were 7% of apparent salt consumption and 8% less than those of 1972. Net imports (imports minus the exports) were almost identical for the past 2 years.

Salt imports in 1973 were five times the tonnage of exports, and the unfavorable balance of trade in salt amounted to $8.06 million. Thirty-four percent of the salt imports came from Canada, 31% from Mexico, and 27% from the Bahamas. Chile and the Netherlands Antilles each contributed about 4%.

Table 9.—Salt shipped to the Commonwealth of Puerto Rico and overseas areas administered by the United States

Area	1972		1973	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
American Samoa	545	$23	505	$24
Puerto Rico	20,055	2,247	17,262	1,543
Virgin Islands	478	33	346	18

Table 10.—U.S. exports of salt, by country

(Thousand short tons and thousand dollars)

Destination	1972 Quantity	1972 Value	1973 Quantity	1973 Value
Australia	(1)	9	(1)	4
Bahamas	2	86	3	118
Canada	627	3,780	561	3,383
Costa Rica	1	29	(1)	29
Honduras	1	23	(1)	19
Jamaica	--	--	1	14
Japan	220	924	26	102
Mexico	3	68	5	87
Netherlands Antilles	1	64	1	69
New Zealand	1	36	1	31
Panama	1	49	1	63
Philippines	2	16	1	7
Saudi Arabia	1	141	2	167
South Africa, Republic of	2	17	1	20
Trinidad and Tobago	1	13	(1)	15
United Arab Emirates	(1)	5	2	44
Other	6	284	4	228
Total	869	5,544	609	4,400

[1] Less than ½ unit.

Table 11.—U.S. imports for consumption of salt, by country

(Thousand short tons and thousand dollars)

Country	1972 Quantity	1972 Value	1973 Quantity	1973 Value
Bahamas	875	3,429	869	3,735
Canada	1,001	4,581	1,079	5,421
Chile	182	493	143	645
Mexico	1,250	2,858	973	2,166
Netherlands Antilles	--	--	123	440
Panama	31	84	--	--
Tunisia	45	131	--	--
United Kingdom	19	160	(1)	2
Venezuela	60	181	--	--
Other	(1)	62	(1)	48
Total	3,463	11,979	3,187	12,457

[1] Less than ½ unit.

Table 12.—U.S. imports for consumption of salt, by class

(Thousand short tons and thousand dollars)

Year	In bags, sacks, barrels or other packages (dutiable) Quantity	In bags, sacks, barrels or other packages (dutiable) Value	Bulk (dutiable) Quantity	Bulk (dutiable) Value
1971	27	574	[1] 3,828	[1] 13,855
1972	26	535	3,437	11,444
1973	27	559	3,160	11,898

[1] Includes salt brine from Canada through Buffalo customs district 1,000 short tons ($1,089); Seattle customs district 28,738 short tons ($198,108).

Table 13.—U.S. imports for consumption of salt, by customs district

(Thousand short tons and thousand dollars)

Customs district	1972 Quantity	1972 Value	1973 Quantity	1973 Value
Baltimore, Md	261	863	176	746
Boston, Mass	213	482	68	152
Buffalo, N.Y	40	191	19	95
Chicago, Ill	61	273	33	169
Cleveland, Ohio	31	151	122	595
Detroit, Mich	559	2,752	588	2,950
Duluth, Minn	43	204	59	329
Los Angeles, Calif	194	423	162	409
Milwaukee, Wis	174	806	234	1,151
Mobile, Ala	--	--	17	70
New York City	142	551	201	756
Norfolk, Va	12	48	35	147
Ogdensburg, N.Y	4	24	10	31
Philadelphia, Pa	36	103	(1)	3
Portland, Maine	396	1,724	194	1,140
Portland, Oreg	320	745	302	685
Providence, R.I	28	86	25	76
St. Albans, Vt	53	3	(1)	4
San Juan, P.R	200	803	135	541
Savannah, Ga	223	827	251	932
Seattle, Wash	444	814	497	1,002
Wilmington, N.C	29	89	59	442
Other	(1)	17	(1)	32
Total	3,463	11,979	3,187	12,457

[1] Less than ½ unit.

Table 14.—U.S. imports for consumption of salt, by use

(Thousand short tons)

Use	1972	1973
Government (highway use)	1,987	1,227
Chemical industry	208	970
Water conditioning service companies	144	129
Other	493	422
Total	[1] 2,831	2,748

[1] Data does not add to total shown because of independent rounding. Disagreement with totals in tables 1, 11, 12, and 13 is because of incomplete data on the uses of imported salt.

WORLD REVIEW

Canada.—Canada ranked eighth in world production of salt in 1973. Sixty-nine percent of its production was mined in the form of rock salt, 17% as salt in brine, and the remainder was evaporated. Areawise, 75% of the salt production came from the Province of Ontario, 15% from Nova Scotia, 6% from Alberta, and 4% from Saskatchewan. In Ontario, as many as six salt layers have been identified at depths of 900 to 2,700 feet. The total thickness of all beds may be as much as 700 feet. Test drilling in the Magdalen Islands encountered salt at 450 feet and was still in salt at 2,000 feet when the drilling was terminated. The two major uses for salt in Canada were highway deicing at 42% of the production and industrial chemicals at 33%. Hooker Chemical Div. and Dow Chemical of Canada Ltd. each announced plans for expanding their chlorine-alkali production facilities which, of course, will consume more salt.

China, People's Republic of.—Solar evaporation of seawater remained the mainstay of the world's second largest salt-producing country, the People's Republic of China (PRC).[6] The Tung-feng salt Field in Shantung and the Tang-ku Field of Hopeh were major areas for extraction of sea salt. Other salterns were located in Kiangsu, Liaoning, and Hainan Island. Lake salt was treated in Tsinghai where other byproducts such as bromine, borates, potassium and barium salts were also recovered. Rock salt was mined in Yunnan, Kiangsi, and Hunan. Most of the Chinese salt was used in food, but there was an increase in industrial applications. Surplus salt was exported, largely to Japan. During 1973, there were serious negotiations on the price of salt between the PRC and Japan. The Japanese threatened to turn to Australia or Mexico for salt if differences in price could not be resolved.

Japan.—Although Japan produced only 1 million tons of salt in 1973, 7.27 million tons were imported to make the country one of the larger world salt consumers. The three major suppliers of salt to Japan were Australia (44%), Mexico (42%), and PRC (13%). The Australian salt industry was developed primarily to supply the Japanese market. In 1973, Japan produced 3.23 million tons of caustic soda and 1.36 million tons of soda ash, both of which utilize salt as a raw material.

Mexico.—The world's largest solar salt production facility, Exportadora de Sal, S.A., located in the Black Warrior district of Baja California, has been purchased by the Mitsubishi Corp. of Japan for a reported $20 million. The present capacity of the plant is about 5 million tons per year. Mitsubishi may extract bromine, magnesium hydroxide, and other byproducts as well as salt from these fields.

U.S.S.R.—The U.S.S.R. ranks third in world production of salt, but details of its industry are not well known. One of the most enlightening papers on the subject was presented at the 1969 Symposium on Salt in Cleveland, Ohio.[7] The total resources of Soviet salt were placed at 255 trillion (10^9) tons. Two large salt-producing areas were identified as Lake Elton in the northern part of the Caspian depression and Lake Baskunchak. About 36% of the Soviet salt comes from underground mines

[6] Canadian Mining Journal. Salt. V. 94, No. 1, January 1973, p. 25.

[7] Panteleyev, N. Soviet Salt Industry Proceedings of the Fourth Symposium on Salt.

Table 15.—Salt: World production, by country

(Thousand short tons)

Country [1]	1971	1972	1973 p
North America:			
Bahamas	1,337	890	1,236
Canada	5,542	5,417	5,327
Costa Rica	12	13	14
Dominican Republic	42	e 43	e 43
El Salvador	34	32	39
Honduras e	30	30	30
Martinique e	330	330	330
Mexico	4,806	5,025	e 5,100
Nicaragua	20	r e 17	e 11
United States (including Puerto Rico):			
Rock salt	13,700	14,434	12,347
Other salt:			
United States	30,377	30,587	31,564
Puerto Rico	29	29	29
South America:			
Argentina	r 908	1,107	e 1,110
Brazil	1,628	2,400	2,044
Chile	469	482	380
Colombia:			
Rock salt	372	384	518
Other salt	331	743	929
Peru	204	e 210	e 210
Venezuela e	290	290	290
Europe:			
Austria:			
Rock salt	1	1	1
Other salt	r 527	548	600
Bulgaria	103	115	120
Czechoslovakia	237	240	e 240
Denmark [2]	147	337	e 310
France:			
Rock salt and brine salt	4,679	4,664	4,944
Marine salt	1,378	1,109	e 1,100
Germany:			
East	2,448	2,411	e 2,400
West (marketable):			
Rock salt	7,407	6,644	7,727
Marine salt and other	2,427	2,685	e 2,700
Greece	126	e 130	e 130
Italy:			
Rock salt and brine salt	r 3,738	3,636	4,086
Marine salt	1,304	793	e 800
Malta	3	r e 2	(3)
Netherlands	3,491	3,090	3,355
Poland:			
Rock salt	1,346	1,333	1,389
Other salt	1,916	1,985	2,005
Portugal:			
Rock salt	259	315	332
Marine salt	178	234	e 230
Romania	3,250	3,469	e 3,600
Spain:			
Rock salt	1,311	1,253	e 1,260
Marine salt [4]	870	731	e 740
Switzerland	321	282	e 290
U.S.S.R	13,200	13,400	13,400
United Kingdom:			
Rock salt	r 2,044	1,430	e 1,300
Other salt e	8,300	9,300	8,900
Yugoslavia	387	296	365
Africa:			
Algeria	128	119	e 120
Angola	100	138	107
Egypt, Arab Republic of	464	422	e 440
Ethiopia: [5]			
Rock salt	11	11	--
Marine salt	309	309	118
Ghana	52	e 55	e 55
Kenya	48	31	34
Libya e	18	18	18
Malagasy Republic	31	23	e 22
Mali	3	e 3	e 3
Mauritius	6	6	e 7
Morocco	59	50	30
Mozambique	31	34	e 34
Senegal	128	149	e 154
Somali Republic e	2	2	2
South Africa, Republic of	389	408	431

See footnotes at end of table.

Table 15.—Salt: World production, by country—Continued

(Thousand short tons)

Country [1]	1971	1972	1973 p
Africa—Continued			
South-West Africa: Marine salt e	121	121	121
Sudan	64	66	83
Tanzania	r 41	e 44	e 44
Tunisia	387	364	391
Uganda	3	e 3	e 3
Asia:			
Afghanistan [5] e	42	42	42
Bangladesh e	140	350	830
Burma	177	174	213
China, People's Republic of e	18,200	19,800	20,000
Cyprus	7	6	e 7
India	5,986	7,187	7,721
Indonesia	47	198	e 220
Iran [5]	430	440	e 440
Iraq	60	e 60	e 70
Israel	88	68	68
Japan	1,043	757	1,119
Jordan	26	26	28
Khmer Republic	143	40	e 44
Korea, North e	600	600	600
Korea, Republic of	397	498	818
Kuwait	e 3	5	e 6
Laos	(3)	9	10
Lebanon e	42	44	44
Malaysia	NA	23	e 30
Mongolia e	10	11	12
Pakistan:			
Rock salt	380	399	417
Other salt	293	258	112
Philippines	260	242	243
Ryukyu Islands	6	6	6
Sri Lanka	95	174	e 190
Syrian Arab Republic	26	e 33	e 33
Taiwan	738	485	347
Thailand e	180	180	180
Turkey	730	e 730	e 730
Vietnam:			
North e	165	165	165
South	132	44	148
Yemen, Arab Republic of	43	81	1
Yemen, People's Democratic Republic of	73	e 70	e 70
Oceania:			
Australia	r 4,243	e 4,400	e 4,400
New Zealand	48	64	e 70
Total	r 159,107	162,941	165,526

e Estimate. p Preliminary. r Revised. NA Not available.

[1] Salt is produced in many other countries, including Cape Verde Islands, Mauritania, and Niger, but quantities are relatively insignificant or reliable data are not available.

[2] 1971 data are sales.

[3] Less than ½ unit.

[4] Revised to include a small quantity of salts produced from brine springs, also includes an average annual production in the Canary Islands of 15,000 metric tons of marine salt.

[5] Year beginning March 21 of year stated.

such as the Solotvinsky mine in the Transcarpathia and the Iletsky mine in the Orenburg Region near the Ural mountains. The mines are well mechanized, and the processing plants are located on the surface near the mine shafts. For home use, the salt is crushed and screened to about 1-millimeter particle size and packed in paper packages weighing 1.5 or 2.2 pounds each. The salt industry of the U.S.S.R. employs about 7,000 workmen. About 1.5 million tons of common salt is used by cattle farmers. The amount going to industry is increasing.

United Kingdom.—An excellent publication of the salt industry of the United Kingdom was issued in 1973 by the Mineral Resources Consultative Committee.[8] It covered the occurrence, reserves, production, industry, uses, trade, prices, technology, and predicted demands for salt. The United Kingdom was the fifth largest salt producer in the world, and its usage pattern was quite similar to that of the United States. Sixty-three percent of the British salt was produced as brine for use primarily in the chemical industry, 19% as evaporated salt for food, agriculture, and other miscellaneous uses, and 18% was mined as rock salt primarily for deicing highways.

[8] Notholt, A. J. G., and D. E. Highley, compilers. Mineral Dossier No. 7—Salt. Her Majesty's Stationery Office, London, 1973.

TECHNOLOGY

It has recently become recognized that salt domes, such as those along the U.S. coast of the Gulf of Mexico, can be practically inexhaustible sources of heat for power generation.[9] Salt has an unusually high thermal conductivity and can, therefore, be expected to act as an energy conduit to bring heat up from the interior of the earth. Typical temperatures within a salt dome are 330° F at 10,000 feet; 455° F at 15,000 feet; and 580° F at 20,000 feet. These temperatures can be maintained indefinitely, it is believed, regardless of the heat extracted from the salt dome. One possible method of bringing the heat to the surface would be to inject water into the cavity and to direct the steam, thus created, through a turbine which would turn an electric generator. The condensed steam from the turbine could be recycled into the salt cavity.

A 3-year testing program by the Dow Chemical Company at Freeport, Tex., has shown that aluminum alloys have exceptional resistance to corrosion caused by hot brine.[10] The equipment for the test was a multistage, flash-distillation desalting plant of the Materials Test Center for the Office of Saline Water. The alloys tested displayed excellent performance under conditions of low pH, high temperatures, and high flow rates. The tested metals cost about half of that required for comparable cupronickel commonly used for such purposes. National capacity for desalting seawater and brackish inland water is increasing rapidly, therefore the usage of lower cost aluminum should become immediately applicable.

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[9] Jacoby, Charles H. and Dilip K. Paul. Salt Domes as a Source of Geothermal Energy. Mining Engineering, V. 26, No. 5, May 1974, pp. 34–39.

[10] Verink, E. D., Jr. Aluminum Alloys for Saline Waters. Chem. Eng., v. 81, No. 8, Apr. 15, 1974, pp. 104–110.

Sand and Gravel

By Walter Pajalich [1]

Sand and gravel production increased about 7% to 984 million short tons. The value of production increased about 13%. Output from commercial operations was 86% of the total output; Government-and-contractor production was 14%. The production of sand and gravel in the Nation's leading State, California, was the same as in 1972, 117 millon short tons.

DOMESTIC PRODUCTION

California, with 117 million tons, ranked first in sand and gravel output and produced about twice as much as second-ranked Michigan. Other States producing substantial quantities of sand and gravel, in descending order of production, were Ohio, Illinois, Wisconsin, Texas, and Minnesota. Combined production from the seven leading States was 389 million tons, about 40% of the total U.S. output. The value of sand and gravel produced in these seven States was $526 million, 39% of the Nation's total. The number of commercial plant operations increased from 5,384 in 1972, to 5,681 in 1973. This was due in part to increased coverage of the industry.

Factors that have added to the consumer cost of sand and gravel included increased labor costs, growing land values, cost of land rehabilitation, and longer haulage distances.

There were 4,496 commercial plant operations with production under 200,000 tons per year. These operations accounted for 30% of the total U.S. commercial production. There were 814 plant operations with production between 200,000 and 500,000 tons, and they accounted for 30% of production. The remaining 371 plant operations, with production over 500,000 tons, accounted for 40% of production.

The use of larger operating units, more efficient portable and semiportable plants, versatility of plant capacity, and greater awareness of pollution control and land rehabilitation were the keynotes of progress in 1973.

Dravo Corp. started constructing a $3.3 million sand and gravel plant at Georgetown, Pa., near the Ohio-West Virginia border. The plant, with an initial capacity of 960,000 tons per year, will process materials dredged from the Ohio River and from the company's 125-acre land deposit in Green Township. The plant will eventually be expanded to 1.5 million tons per year. Reclamation plans for the site include a 100-acre lake and recreation area.[2]

The first phase of Pennsylvania Glass Sand Corp.'s expansion program at its operation at Columbia, S.C., has been completed. The Columbia plant supplies high-quality silica sand for glass, fiberglass, ceramic, and chemical industries in the Southeast. When the $2.5 million expansion is completed, milling capacity will be doubled. The expansion program was to be completed sometime in 1975.[3]

Modernization of the Martin Marietta Corp. silica sand plant at Oregon, Ill., included new features that are becoming part of the sand and gravel industry. Plans called for expansion that would increase the present 200-ton-per-hour capacity of finished product by 50%. The major feature is the attention given to dust and noise control and the protection of operating personnel from these factors, plus the outstanding routine program of housekeeping.

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[1] Mining engineer, Division of Nonmetallic Minerals—Mineral Supply.
[2] Rock Products. Rock Newscope. V. 75, No. 10, October 1972, p. 24.
[3] Pit & Quarry. Industry News. V. 65, No. 9, March 1973, p. 6.

All dust-generating phases of the processing operation are fully enclosed, and all dust is collected by a high-capacity dust-collecting facility. Dust produced by dried material at delivery points is controlled by wet scrubbers. The processed water is recycled from a holding pond from which no water can flow into the area's natural drainage system.[4]

The Herbert Materials Co. of Nashville, Tenn., has modernized its main yard with a new system of aggregate storage and reclamation. Now the company can simultaneously load out aggregates for shipment and feed to a pair of ready-mix plants. Sized sand and gravel is delivered by barges from a dredge in the Tennessee River. The firm has two dredges in operation with a total production capacity of 600 tons per hour.[5]

The problem of clay contamination at the Arena deposit of Thorstenberg Materials Co. of Texas has been solved by a battery of eight washing-classifying units. The deposit contains 35% gravel. The remainder is sand and clay. The clay occurs in erratic seams throughout the deposit. The process of removing clay includes the use of four spiral washers, a 40-foot sand classifier and three log washers. Push-button controls regulate the processing, blending, and loading. The plant produces 750 tons of products per hour. Primary market area for the products is Houston and Harris Counties, Texas.[6]

[4] Herod, B. C. Martin Marietta Enlarges and Modernizes Illinois Sand Plant. Pit & Quarry, v. 65, No. 12, June 1973, pp. 62–67.
[5] Trauffer, W. E. Herbert Materials Modernized Nashville Yard and Plants. Pit & Quarry, v. 66, No. 2, August 1973, pp. 64–67, 83.
[6] Robertson, J. L. Washer/Classifier System Solves Clay Problem at Sand & Gravel Plant. Rock Products, v. 76, No. 3, March 1973, pp. 50–54, 96.

Table 1.—Sand and gravel sold or used by producers in the United States,[1] by class of operation and use

(Thousand short tons and thousand dollars)

Class of operation and use	1972 [2] Quantity	1972 [2] Value	1973 [2] Quantity	1973 [2] Value
Construction:				
Building:				
Sand	r 187,314	r 247,784	192,795	271,039
Gravel	r 153,199	r 237,782	156,782	256,229
Paving:				
Sand	r 132,465	r 158,806	141,259	185,464
Gravel	r 280,135	r 335,142	309,254	399,400
Fill:				
Sand	r 49,027	r 33,089	56,061	39,495
Gravel	43,458	29,913	41,566	31,189
Railroad ballast:				
Sand	1,045	1,186	876	1,032
Gravel	2,229	2,332	2,743	3,663
Other:				
Sand	r 9,560	r 10,274	12,066	14,757
Gravel	12,880	14,247	19,715	20,157
Total construction [3]	r 871,312	r 1,070,555	933,118	1,222,425
Industrial sand:				
Unground:				
Glass	10,828	41,259	10,158	41,485
Molding	7,522	24,827	7,446	25,540
Grinding and polishing	262	731	359	1,152
Blast sand	1,072	6,278	1,195	6,133
Fire or furnace	703	2,243	1,005	3,214
Engine	601	1,387	835	2,042
Filtration	234	1,176	283	1,368
Oil hydrofrac	282	1,071	352	1,773
Other	3,514	11,868	2,748	8,940
Total [3]	25,018	90,840	24,381	91,648
Ground sand [4]	4,512	21,546	4,593	18,418
Total industrial [3]	29,530	112,386	28,974	110,065
Miscellaneous gravel	13,482	17,759	21,537	26,880
Grand total [3]	r 914,324	r 1,200,701	983,629	1,359,370
Commercial:				
Sand	r 379,540	r 539,202	403,928	586,919
Gravel	r 407,197	r 549,930	442,877	627,639
Government-and-contractor: [5]				
Sand	29,402	24,324	28,103	34,933
Gravel	98,185	87,245	108,721	109,878

r Revised.
[1] Excludes Puerto Rico.
[2] Data not directly comparable with those of previous years because of changes in industry coverage.
[3] Data may not add to totals shown because of independent rounding.
[4] See table 10 for use breakdown.
[5] Approximate figures for operations by States, counties, municipalities, and other government agencies under lease.

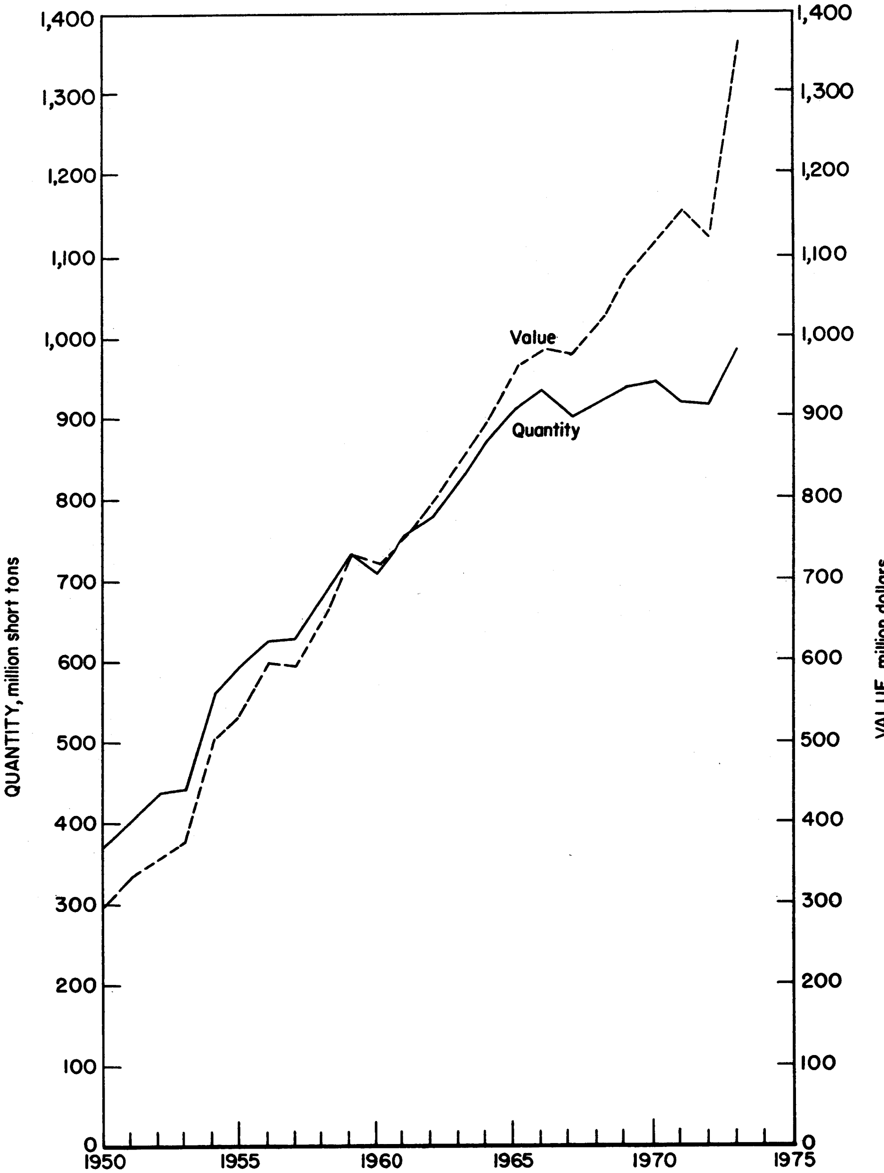

Figure 1.—Production and value of sand and gravel in the United States.

CONSUMPTION AND USES

In 1973, U.S. consumption of sand and gravel amounted to 984 million tons valued at $1.4 billion. The construction industry, the prime user of sand and gravel, consumed 95% of the tonnage, representing 89% of the value of the sand and gravel output in 1973. Of the amount of sand and gravel consumed by the construction industry, 48% went into paving, 38% into building, about 10% into fill, and 4% into other uses. The principal consumers of higher priced industrial sand were the glass and foundry industries.

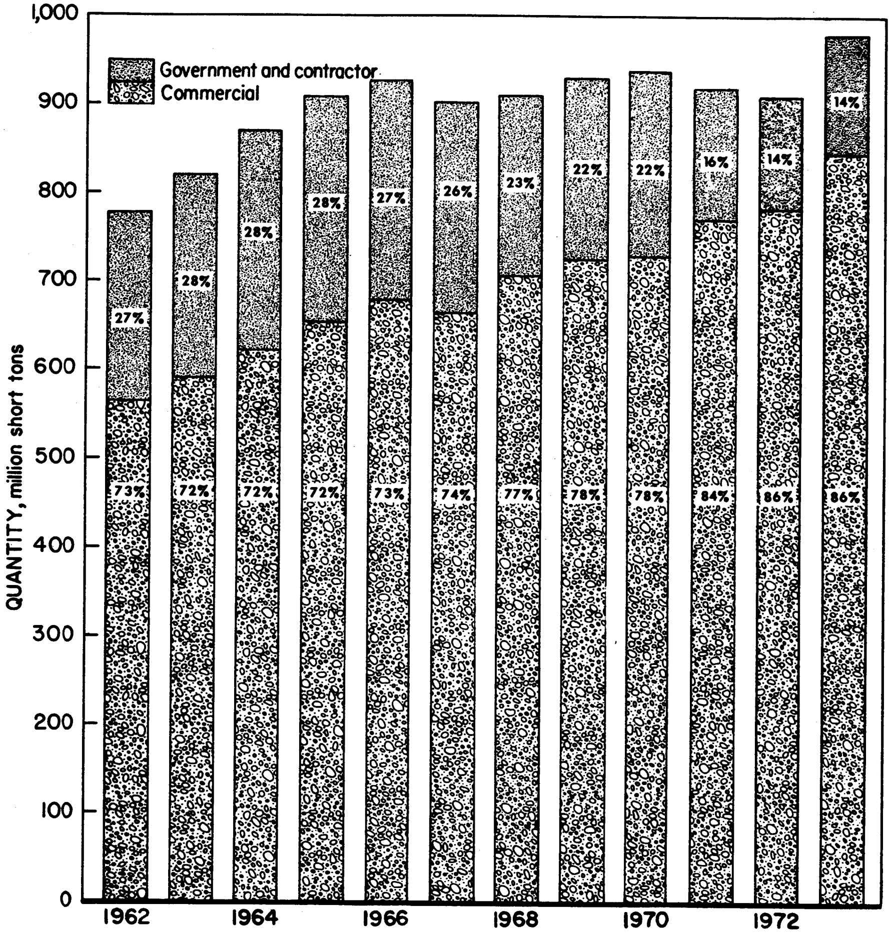

Figure 2.—Sand and gravel sold or used in the United States.

PRICES

Representative carlot-load prices of sand in 18 cities at the end of 1973 ranged from $0.95 per ton in Detroit to $6.45 per ton in Birmingham, according to the Engineering News-Record.[7] The average of the sand prices reported was $3.55 per ton compared with $3.14 per ton in 1972. Prices for either 3/4- or 1 1/2-inch gravel ranged from $1.60 per ton in Birmingham to $5.70 per ton in Los Angeles. The average of the 3/4-inch gravel prices reported for 19 cities was $3.66 per ton, compared with $3.80 per ton in 1972. For 1 1/2-inch gravel, the average for 15 cities was $3.92 per ton compared with $3.74 per ton in 1972.

Based on the Bureau of Mines canvass, the average value of sand and gravel sold or used by producer, f.o.b. plant, was $1.38 per ton; the comparable value in 1972 was $1.31 per ton.

[7] Engineering News-Record. McGraw-Hill Construction Weekly, Dec. 6, 1973, pp. 44–45.

FOREIGN TRADE

Canada received 75% of U.S. exports of construction sand, the Bahamas received 24%, and the Netherlands Antilles received less than 1%. The remainder went to 15 different countries. Exports of construction sand total 422,483 short tons valued at $793,495. Gravel exports totaled 475,894 short tons valued at $666,693. Total exports of common sand and gravel were 898,377 short tons valued at $1,460,168. Canada received 86% of U.S. exports of common sand and gravel, the Bahamas received 12%, and Mexico received 1%. Of U.S. exports of industrial sand, which amounted to 845,359 short tons valued at $7,136,394, Canada received 59%, Mexico 22%, and Japan 13%. The remainder went to 65 different countries.

Most of the crude sand and gravel imported in 1973 was from Canada. Almost all of the imported glass sand was from Australia.

WORLD REVIEW

Denmark.—Hoffman & Sons A/S is one of the suppliers of sand and gravel for the general construction market in the greater Copenhagen area. Mining continues year around despite the rigors of the Danish winter. Fortunately, the material contains only about 2% to 3% moisture and draglines can be used for mining. Average production is 1,000 cubic yards per hour.[8]

Germany, West.—A new, completely enclosed and weatherproof, sand and gravel plant with a 600-ton-per-hour capacity was erected by Gammerer GmbH of Wolfratshausen on a site east of Munich. Two rod mills are part of the installation to produce additional sand.[9]

Japan.—The silica sand resources of Japan are located in a central district including Aichi, Gifu, and Mie Prefectures. Total reserves of the deposits are estimated at 68 million tons. The sand occurs intermixed with clay. Processing involves clay removal by breaking, grinding, water washing, and screening, followed by flotation and magnetic separation. The grade of the sand ranges from 93% to 98% silica. In 1973 production was about 5 million tons. About 2.5 million tons was used in the glass industry and 1.6 million in castings. Selling price ranges from $10 to $13 per ton. About 330,000 tons of silica sand was imported from Australia, South Vietnam, and the Republic of Korea.[10]

Switzerland.—At Bardonnex, a few miles south of Geneva, is an extensive deposit of consolidated glacial gravel. There is also a tile factory at this site. The material for this factory comes from a clay deposit above the glacial gravel. The deposit is so consolidated that blasting is required. Because the natural underground water reservoir for the Geneva public water supply system is below the deposit, careful reclamation of the area had to be considered before permission was granted for gravel extraction. Annual production was about 331,000 tons. As it is generally practiced in Switzerland, the plant is located in a single high building. This gives the operation a neat tidy appearance, facilitates maintenance, and minimizes dust and noise nuisance to the public.[11]

United Kingdom.—Concern has been expressed by the Institute of Geologic Sciences about the size of sand and gravel reserves in the United Kingdom. About 2.5 billion tons has already been excavated. Much of the known reserves are inaccessible. Over the years, construction of new buildings covered up about 49,000 hectares of land around London. This area is estimated to contain about 1 billion tons of sand and gravel. The main concern is the growth in consumption. By contrast, in 1955 annual production was 60 million tons, and in 1973, it was 125 million tons. About 4 million tons of this was exported. Most of the exported material was marine-dredged aggregates. About 12% of the country's sand and gravel is marine dredged, making the United Kingdom the leading country in mining of sand and gravel from the ocean.[12]

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[8] Ironman, R. Danish Plant Work Pit All Winter. Rock Products, v. 76, No. 2, December 1973, pp. 62–63.

[9] Ironman, R. International Report. Rock Products, v. 76, No. 11, November 1973, p. 94.

[10] Kazvo, O. Japan Chemical Week (Tokyo). December 1973, p. 62.

[11] Cement Lime and Gravel. Gravel for Geneva. The Operation of Bardogaves SA. V. 48, No. 12, December 1973, pp. 251–256.

[12] Cement Lime and Gravel. Mineral Resources Survey of Sand Gravel. V. 48, No. 1, January 1973, p. 15.

A Government-appointed consultative committee suggested the use of other suitable alternative materials, from sources other than natural sand and gravel. One of the materials suggested was pulverized ash from coal-fired power stations.

About 75% of the sand and gravel produced was used in concrete. Housing, including site roads, and industrial building together account for the largest proportion of the concrete used.[13]

The Queen Mary Reservoir at Staines Middlesex, constructed in the early 1920's, was built over an area that contained a deposit of sand and gravel, under which is a deposit of clay. The area covers 723 acres. Owing to technical considerations, the depth of the water was set at 40 feet. Now equipment is available that assists the thermal circulation of the water from one level to another. This has made it possible to increase the depth of the reservoir. At a safe distance inside the retaining banks, 420 acres of the floor of the reservoir is available for excavation of sand and gravel. An estimated 10 million tons of sand and gravel will be excavated utilizing 3-cubic-yard dragline. The plant will process an average of 180 tons of sand and gravel per hour.[14]

Kennedy Sand Ltd., one of the largest producers of sand and gravel in northwest England, started a new operation at Whiteley Green, near Bollington, about 3 miles north of Macclesfield. The new mine is primarily a sand producer with a plant capacity of 150 tons per hour. Gravel content is about 10% to 15%. The reserves on the 24 acres are about 2.5 million tons. This will keep the plant in operation for 9 years.[15]

In Scotland, a loosely cemented quartz conglomerate deposit located at Douglasmuir Milngavie Dumbartonshire has been developed as a sand and gravel deposit by Amalgamated Quarries (Scotland) Ltd., of North Queensferry, Fife. The initial facilities were handling 65 tons of material per hour. Expansion to 200 tons per hour was planned for 1974. The deposit is located only 5 miles from central Glasgow. The plant is soundproof and occupies only 12,000 square feet. Landscaping and planting will hide the workings from the road. Production of sand and gravel in Scotland has been declining. Production in 1971 was only 9.1 million tons.[16]

TECHNOLOGY

The use of plastic aggregate in highway and building construction is currently undergoing field test investigation in several parts of the United States. The test site is an industrial plant access road in Jamesburg, N.J. The material, called Styropor, was designed as an insulating subbase to reduce frost action. It is also claimed that the inherent structural strength will permit the use of less subbase in road construction. Styropor is produced in the form of polystyrene beads that contain a foaming agent. The beads expand rapidly to 50 times their original size when exposed to heat, forming perfect closed-cell spheres that trap air inside. The expanded beads are coated with a thin layer of epoxy before being mixed with cement as a cover. The cement hardens in a spherical shape around the expanded beads to develop maximum mechanical strength. Because of its low thermal conductivity, it is claimed that 6 to 9 inches of the new Styropor concrete can replace 24 to 36 inches of gravel road foundation for frost protection.

In one experiment, a 38-pound-per-square-foot density Styropor concrete was laid on a 9-inch-thick bed of subbase instead of a conventional 36-inch thickness of gravel. Therefore, a 12-foot-wide lane in 1 mile of highway would require 910 tons of Styropor concrete (24 tons of Styropor beads) instead of 10,450 tons of gravel. The material is being introduced into the United States by a subsidiary of a large German chemical corporation, which has tested the Styropor aggregate at 13 major sites in northern Europe. The tests were conducted under very cold conditions for several years. The results to date are stated to have been successful.

Developed in Denmark, the synthetic aggregate Synopal produces a light-colored

[13] Ironman, R. International Report. Rock Products, v. 76, No. 7, July 1973, p. 54.
[14] Cement Lime and Gravel. Gravel From a Reservoir. V. 48, No. 1, January 1973, pp. 3–10.
[15] Cement Lime and Gravel. New Sand Source for the Manchester Area. V. 48, No. 11, November 1973, pp. 229–232.
[16] Industrial Minerals. Sand and Gravel Find in Scotland. No. 63, December 1973, p. 39.

asphalt. It was tested for 7 years as a 1-inch overlay on 1½ miles of U.S. 66 near Pontiac, Ill. The advantages of Synopal are greater light reflectivity, greater hardness, and a more skid-resistant surface texture.

Steel fibers 0.0059 to 0.062 inch in diameter, and 0.25 to 2.5 inches long mixed with any aggregate in amounts varying from 0.2% to 4.0% have been used successfully in concrete. The addition of steel fibers to a mortar or concrete improves the thermal stress and shock resistance, impact strength, abrasion resistance, shear strength, and spalling resistance. These are the findings of numerous applications in various concrete construction projects since 1960 when Battelle Development Corp. took over the development of this material. Battelle Development Corp. of Ohio now holds U.S. patent rights under the trademark Wirand. The U.S. Army Construction Engineers Research Laboratory in Champaign, Ill., tested steel fiber concrete pavement alongside ordinary concrete pavement. The steel fibrous pavement was only one-half as thick as the regular pavement. The results of the test showed the steel fiber concrete pavement was able to withstand twice the load and outlasted the regular pavement.[17]

Asphalt containing asbestos in addition to sand and gravel dates from 1960 when the mixture was given field trials. Asbestos additives, usually 2% to 3% by weight, permit the use of upwards of 50% more asphalt in mixes. According to experts, this additional asphalt, previously impractical, is desirable because it increases pavement cohesion and flexibility, resists abrasion, reduces low-temperature cracking, and decreases water permeability. The cost of the asbestos asphalt mix is 15% to 20% more than the standard asbestos-free mix. Roads paved in Rockville Centre, N.Y., over 10 years ago, with only a ½-inch layer of asbestos asphalt, were claimed to still have 3 to 4 years of use before requiring repaving. Original plans called for repaving these streets every 10 years.[18] Asbestos asphalt has been successfully used at locations such as the George Washington Bridge, New Jersey Turnpike, and other roadways in various parts of the country.

Asphalt mixed with latex and sand and gravel is also being used to extend the life of pavement. A combination of rubberized sealant and rubberized asphalt reportedly reduces maintenance costs, particularly during the winter when deicing chemicals are applied.

Finely ground refuse container glass was used instead of limestone dust in producing asphaltic concrete. It was used primarily where extra hard asphalt was needed, such as curbing.[19]

To replenish the Hawaii beaches, a new system has been developed for mining ocean bottoms using a small vessel and a suction probe that buries itself into thick deposits of sand. The Submarine Sand Recovery System was built and tested under the University of Hawaii's Sea Grant Program. The system is expected to provide more economical and ecologically sound means of recovering offshore sand than the conventional dredging systems. With the aid of scuba divers, a probe with a 6-inch-diameter hose attached to the suction tube is allowed to bury itself about 12 feet into the sand. When suction is applied, a mixture of sand and water enters the inlet valve and is drawn to the surface. Coral or shell fragments, which could obstruct sand flow, are crushed by a 4-inch roller crusher in the probe head.[20]

The combustion roar of an asphalt aggregate drying plant measuring 115 decibles was successfully reduced to an 85-decible level with a specially built enclosure at the Russell Industries, Inc., McKees' Rocks, Pa., plant. The enclosure was designed to handle 71,000 cubic feet per minute of air at a pressure drop of 1½ inches of water. A plenum was installed around the burner. The acoustical panels are 4-inch-thick metallic sandwiches with solid outer surface and perforated inner surface. Between the sheets is an inert, durable, noncombustible acoustic fill. In addition to reducing the noise level, the enclosure prevented the atmospheric loss of burner heat, resulting in hotter air being passed to the rotary dryer. This unexpected benefit reduced gas consumption[21] between 4% to 6%.

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[17] Roth, L. New Methods/Report 109. Rocky Mountain Construction, v. 54, No. 9, May 1, 1973, pp. 42, 50.

[18] Olton, R. C. Asbestos-Asphalt Paving Gives Streets Longer Life. American City Magazine, v. 88, No. 9, 1973.

[19] Road & Streets. New Uses for Ground Glass: Asphaltic Concrete. V. 110, No. 9, September 1973, p. 129.

[20] Casciano, F. Submarine Sand Recovery System Developed for Hawaii's Beaches. World Dredging & Marine Construction, v. 9, No. 12, October 1973, pp. 24-27.

[21] Road & Streets. Noise Control Enclosure Improves Dryer Efficiency. V. 116, No. 9, September 1973, pp. 142, 144.

A worked-out sand and gravel pit was successfully turned into a sanitary landfill operation. Rockford Black Top Construction Co., of Rockford, Ill., owners of the pit, first graded and then lined the botttom and side slopes of the pit with 2 inches of hot asphalt mix. An asphalt dike along the inside edge of the pavement prevents the leachate from contaminating soil in unpaved areas. Four peripheral wells monitor the ground water for contamination. The landfill, referred to as the Winnebago County Land Reclamation Site, serves a population of 200,000. When the backfill is completed, the pit will become useful level land.[22]

[22] Hill, A. D. Pave Old Gravel Pit—Town Gets Sanitary Land Fill. Road & Streets. v. 116, No. 8, August 1973, p. 104.

Table 2.—Sand and gravel sold or used by producers in the United States[1]

(Thousand short tons and thousand dollars)

Year	Sand		Gravel		Total [2]	
	Quantity	Value	Quantity	Value	Quantity	Value
1969	380,878	465,843	556,291	603,826	937,169	1,069,667
1970	383,378	484,722	560,563	630,985	943,941	1,115,705
1971	400,759	516,749	518,833	632,226	919,593	1,148,969
1972 r	408,942	563,526	505,382	637,175	914,324	1,200,701
1973	432,031	621,853	551,598	737,518	983,629	1,359,370

r Revised.
[1] Excludes American Samoa, Puerto Rico, and the Canal Zone.
[2] Data may not add to totals shown because of independent rounding. Data not directly comparable with those of previous years because of changes in industry coverage.

Table 3.—Sand and gravel sold or used by producers in the United States, by State, and class of operation

(Thousand short tons and thousand dollars)

State	1972 Commercial Quantity	1972 Commercial Value	1972 Government-and-contractor Quantity	1972 Government-and-contractor Value	1972 Total[1] Quantity	1972 Total[1] Value	1973 Commercial Quantity	1973 Commercial Value	1973 Government-and-contractor Quantity	1973 Government-and-contractor Value	1973 Total[1] Quantity	1973 Total[1] Value
Alabama	6,352	8,530	--	--	6,352	8,530	9,798	13,860	7	10	9,805	13,870
Alaska	4,252	4,183	9,936	11,031	14,187	15,214	4,396	7,019	10,602	12,893	14,999	19,913
Arizona	22,619	29,131	2,223	3,290	24,842	32,420	24,610	33,029	2,830	5,473	27,440	38,503
Arkansas	10,004	15,045	1,571	1,514	11,574	16,558	11,103	19,623	1,361	1,002	12,465	20,625
California	104,419	154,544	12,869	8,075	117,288	162,619	98,879	151,442	18,591	24,844	117,470	176,286
Colorado	22,211	30,285	6,106	4,346	28,318	34,631	24,427	35,670	9,341	9,824	33,767	45,493
Connecticut	5,924	9,560	839	1,710	6,763	11,270	7,471	12,088	335	701	7,806	12,788
Delaware	2,257	2,660	--	--	2,257	2,660	3,408	3,678	--	--	3,408	3,678
Florida	r 22,318	r 16,963	45	45	r 22,363	r 17,009	20,120	21,366	47	49	20,167	21,415
Georgia	3,816	4,729	--	--	3,816	4,729	4,976	6,781	--	--	4,976	6,781
Hawaii	584	1,890	25	3	609	1,893	753	2,012	--	--	753	2,012
Idaho	3,825	5,896	3,871	4,398	7,696	10,294	5,494	7,882	2,899	2,363	8,393	10,246
Illinois	39,533	61,328	397	368	39,929	61,696	43,170	61,559	479	470	43,649	62,029
Indiana	26,652	32,348	1,326	943	27,978	33,290	27,013	34,323	718	692	27,731	35,015
Iowa	15,772	19,064	1,335	1,076	17,107	20,140	18,661	24,373	1,289	1,168	19,950	25,541
Kansas	9,265	9,588	2,326	1,333	11,591	10,920	11,074	10,938	2,187	1,725	13,261	12,663
Kentucky	8,321	11,919	163	48	8,485	11,967	10,202	14,400	128	227	10,331	14,627
Louisiana	18,538	26,255	383	740	18,920	26,996	13,676	21,127	72	37	13,748	21,165
Maine	4,126	4,394	7,692	3,140	11,818	7,535	4,783	4,694	8,800	5,610	13,583	10,304
Maryland	12,426	26,517	167	40	12,594	26,557	12,743	29,552	101	73	12,845	29,625
Massachusetts	16,568	23,782	2,315	1,873	18,883	25,655	17,451	24,271	1,292	2,639	18,743	26,910
Michigan	54,683	63,646	4,784	1,799	59,467	65,445	56,609	69,945	5,799	4,027	62,407	73,972
Minnesota	30,451	29,972	6,341	3,482	36,792	33,454	33,463	36,317	4,472	3,121	37,935	39,438
Mississippi	13,295	15,867	124	266	13,419	16,133	14,070	17,057	181	326	14,251	17,383
Missouri	10,068	14,779	14	27	10,082	14,806	10,825	16,905	54	45	10,879	16,950
Montana	2,138	3,022	7,977	14,126	10,116	17,149	2,677	3,366	9,016	10,453	11,694	13,819
Nebraska	12,317	13,376	1,403	1,688	13,720	15,063	14,396	16,492	1,509	1,874	15,906	18,366
Nevada	7,722	10,691	2,359	1,945	10,081	12,636	8,470	12,394	3,978	2,219	12,448	14,614
New Hampshire	4,815	5,951	1,204	305	6,020	6,256	6,689	8,215	1,105	382	7,795	8,597
New Jersey	17,666	38,010	13	11	17,679	38,020	19,036	43,093	4	6	19,040	43,098
New Mexico	5,609	6,894	1,991	1,659	7,600	8,553	7,203	10,365	3,438	5,388	10,641	15,753
New York	24,594	36,321	2,128	631	26,722	36,952	27,614	40,613	1,930	783	29,544	41,396
North Carolina	r 9,410	r 12,400	3,413	1,413	r 12,823	r 13,812	13,010	17,346	2,887	1,981	15,897	19,327
North Dakota	4,708	4,678	1,974	1,078	6,681	5,757	4,285	4,807	1,726	1,214	6,011	6,021
Ohio	43,276	59,702	229	230	43,506	59,932	48,748	69,733	239	249	48,987	69,982
Oklahoma	7,306	10,181	595	957	7,901	11,138	11,112	13,650	1,042	1,291	12,154	14,941
Oregon	20,736	30,462	3,753	4,519	24,489	34,981	19,048	26,984	3,754	5,766	22,802	32,751
Pennsylvania	18,757	36,804	--	--	18,757	36,804	20,576	42,830	--	--	20,576	42,830
Rhode Island	2,008	3,265	71	71	2,079	3,336	2,406	3,071	23	23	2,429	3,095
South Carolina	7,916	12,121	--	--	7,916	12,121	8,159	12,608	20	20	8,179	12,628
South Dakota	5,772	6,423	6,976	8,369	12,748	14,793	6,262	7,300	7,702	9,287	13,963	16,587

See footnotes at end of table.

Table 3.—Sand and gravel sold or used by producers in the United States, by State, and class of operation—Continued

(Thousand short tons and thousand dollars)

State	1972						1973					
	Commercial		Government-and-contractor		Total [1]		Commercial		Government-and-contractor		Total [1]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Tennessee	10,441	15,157	398	172	10,839	15,328	11,457	19,883	554	262	12,010	20,145
Texas	33,036	54,658	2,115	1,670	35,151	56,328	35,740	58,098	2,806	2,608	38,546	60,706
Utah	11,652	13,989	2,967	3,082	14,619	17,071	12,287	12,804	3,124	3,183	15,410	15,986
Vermont	2,477	3,014	825	199	3,302	3,214	2,468	3,048	1,573	533	4,041	3,581
Virginia	13,976	21,648	109	48	14,085	21,696	14,359	26,186	152	59	14,511	26,246
Washington	18,264	23,440	4,801	2,629	23,065	26,069	22,662	26,666	5,273	3,466	27,935	30,132
West Virginia	5,765	15,030	(2)	1	5,765	15,031	5,893	16,257	--	--	5,893	16,257
Wisconsin	24,418	24,880	12,012	6,443	36,430	31,324	29,651	34,363	10,600	9,284	40,250	43,647
Wyoming	3,678	4,142	5,419	10,774	9,098	14,916	3,419	4,475	2,783	7,160	6,201	11,635
Total [1]	r 786,737	r 1,089,132	127,587	111,569	r 914,324	r 1,200,701	846,805	1,214,559	136,824	144,811	983,629	1,359,370
Puerto Rico e p	7,246	20,446	232	792	7,478	21,237	7,247	20,448	233	795	7,480	21,243

e Estimate. p Preliminary. r Revised.

[1] Data may not add to totals shown because of independent rounding. Data not directly comparable with previous years because of changes in industry coverage.

[2] Less than ½ unit.

Table 4.—Sand and gravel sold or used by producers in the United States in 1973, by State, use, and class of operation

(Thousand short tons and thousand dollars)

State	Sand, construction							
	Building				Paving			
	Commercial		Government-and-contractor		Commercial		Government-and-contractor	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	2,491	2,832	--	--	1,452	2,274	3	4
Alaska	301	860	6	47	14	55	2,881	3,615
Arizona	4,695	8,069	(1)	(1)	1,571	2,029	645	884
Arkansas	3,010	4,621	--	--	1,745	3,174	305	226
California	22,276	34,924	(1)	1	17,856	24,316	4,766	9,576
Colorado	3,587	5,765	57	122	1,760	2,375	710	1,008
Connecticut	1,661	2,748	--	--	1,498	2,754	27	24
Delaware	503	880	--	--	230	349	--	--
Florida	10,299	11,522	--	--	2,246	2,758	--	--
Georgia	3,497	3,501	--	--	306	543	--	--
Hawaii	461	1,394	--	--	32	27	--	--
Idaho	852	1,431	18	7	55	98	36	71
Illinois	6,960	8,829	--	--	9,769	12,641	12	18
Indiana	4,682	5,613	--	--	6,852	7,779	28	60
Iowa	3,227	4,320	1	1	3,414	4,366	177	215
Kansas	3,407	3,710	--	--	2,629	2,784	885	677
Kentucky	4,527	6,701	--	--	2,898	3,916	20	81
Louisiana	2,918	3,986	--	--	2,172	2,756	--	--
Maine	518	629	5	5	1,054	1,035	171	156
Maryland	5,791	12,702	--	--	735	1,753	9	7
Massachusetts	3,589	5,209	3	6	2,091	2,451	245	504
Michigan	8,381	8,315	61	45	7,517	8,093	994	712
Minnesota	5,675	6,084	2	2	4,060	3,362	316	211
Mississippi	2,019	2,157	59	97	2,313	2,391	29	15
Missouri	3,953	4,887	--	--	1,681	1,978	--	--
Montana	379	728	--	--	69	169	334	299
Nebraska	4,006	4,301	--	--	1,485	1,681	315	370
Nevada	1,214	2,212	--	--	198	285	111	149
New Hampshire	1,021	1,252	--	--	887	892	514	245
New Jersey	6,057	9,739	--	--	2,973	4,138	--	--
New Mexico	1,543	1,989	--	--	218	219	564	1,552
New York	9,751	15,174	--	--	2,598	4,038	9	18
North Carolina	4,878	5,209	--	--	2,401	2,697	1,284	863
North Dakota	463	633	--	--	110	97	89	56
Ohio	7,660	10,393	9	14	9,785	13,074	95	107
Oklahoma	4,418	4,831	5	3	2,468	2,655	211	89
Oregon	1,570	2,532	--	--	646	1,029	1,040	2,081
Pennsylvania	5,366	10,747	--	--	3,625	7,293	--	--
Rhode Island	500	571	--	--	443	574	8	8
South Carolina	4,571	3,869	--	--	648	425	--	--
South Dakota	878	1,182	--	--	266	351	275	315
Tennessee	3,460	5,801	--	--	1,501	2,782	--	--
Texas	10,868	16,154	(1)	(1)	5,465	6,647	373	195
Utah	1,546	1,901	--	--	446	514	24	18
Vermont	544	790	--	--	561	695	1,029	313
Virginia	3,441	5,957	--	--	2,769	4,146	35	20
Washington	3,029	4,270	--	--	1,190	1,431	26	58
West Virginia	1,685	2,895	--	--	596	1,106	--	--
Wisconsin	3,986	5,043	8	2	2,059	1,875	1,718	1,611
Wyoming	437	811	11	20	371	546	1,214	3,618
Undistributed	--	--	--	--	--	--	--	--
Total [2]	192,550	270,670	246	369	119,730	155,414	21,529	30,050
Puerto Rico [e p]	2,324	6,074	190	644	1,148	3,055	42	148

See footnotes at end of table.

Table 4.—Sand and gravel sold or used by producers in the United States in 1973, by State, use, and class of operation—Continued

(Thousand short tons and thousand dollars)

State	Sand, construction—Continued									
	Railroad ballast (commercial)		Fill				Other [3]			
			Commercial		Government-and-contractor		Commercial		Government-and-contractor	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	W	W	140	102	--	--	127	177	--	--
Alaska	--	--	W	W	34	30	--	--	--	--
Arizona	W	W	654	418	35	11	W	W	--	--
Arkansas	W	W	249	204	--	--	21	23	--	--
California	W	W	4,395	3,895	875	266	88	308	69	153
Colorado	W	W	264	181	1	2	376	665	2	3
Connecticut	--	--	396	328	34	34	W	W	54	34
Delaware	--	--	552	443	--	--	--	--	--	--
Florida	--	--	6,183	3,128	--	--	243	W	--	--
Georgia	--	--	333	182	--	--	60	74	--	--
Hawaii	--	--	W	W	--	--	W	W	--	--
Idaho	--	--	125	112	20	14	W	W	12	19
Illinois	--	--	2,764	2,746	1	1	513	556	1	1
Indiana	W	W	1,144	996	--	--	163	145	59	101
Iowa	W	W	1,598	1,231	(1)	(1)	1,007	1,253	7	9
Kansas	--	--	2,252	1,458	1	(1)	698	611	103	109
Kentucky	--	--	407	358	--	--	110	W	--	--
Louisiana	--	--	490	366	37	11	W	W	22	17
Maine	--	--	630	214	3	1	171	111	39	23
Maryland	--	--	410	808	--	--	1	W	--	--
Massachusetts	--	--	613	460	25	13	856	1,147	21	29
Michigan	--	--	2,501	1,344	803	437	367	325	150	107
Minnesota	W	W	1,343	827	46	33	128	76	14	10
Mississippi	W	W	35	23	--	--	W	W	--	--
Missouri	--	--	613	571	--	--	95	165	--	--
Montana	W	W	80	62	2	2	W	W	3	9
Nebraska	W	W	689	495	--	--	W	W	1	1
Nevada	--	--	585	385	83	36	148	W	(1)	(1)
New Hampshire	W	W	1,513	1,072	4	1	54	49	--	--
New Jersey	--	--	933	651	--	--	49	107	--	--
New Mexico	--	--	154	142	47	36	W	W	(1)	(1)
New York	6	2	2,769	1,282	107	31	548	791	385	178
North Carolina	--	--	580	364	754	469	63	103	398	287
North Dakota	--	--	201	235	87	40	W	W	--	--
Ohio	W	W	1,870	1,610	--	--	472	641	--	--
Oklahoma	--	--	2,525	1,246	712	1,101	71	15	23	5
Oregon	4	6	1,211	1,100	--	--	W	W	--	--
Pennsylvania	--	--	123	182	--	--	1,431	2,221	--	--
Rhode Island	--	--	56	64	--	--	W	W	--	--
South Carolina	--	--	272	130	20	20	W	W	--	--
South Dakota	W	W	302	295	1	1	12	21	--	--
Tennessee	--	--	418	430	--	--	W	W	--	--
Texas	W	W	1,279	861	5	16	89	120	13	39
Utah	--	--	895	286	30	16	W	W	--	--
Vermont	--	--	55	40	--	--	43	45	19	16
Virginia	W	W	2,216	1,518	108	35	86	181	1	1
Washington	W	W	2,495	1,811	--	--	166	378	74	53
West Virginia	--	--	W	W	--	--	--	--	--	--
Wisconsin	--	--	1,726	1,066	248	74	449	495	665	372
Wyoming	--	--	26	12	69	207	--	--	(1)	(1)
Undistributed	869	1,023	806	822	--	--	1,222	2,375	--	--
Total [2]	876	1,032	51,869	36,557	4,192	2,938	9,929	13,181	2,137	1,576
Puerto Rico [e p]	--	--	657	714	--	--	--	--	--	--

See footnotes at end of table.

Table 4.—Sand and gravel sold or used by producers in the United States in 1973, by State, use, and class of operation—Continued

(Thousand short tons and thousand dollars)

State	Sand, industrial (commercial)									
	Glass		Molding		Grinding and polishing		Blast sand		Fire or furnace	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	--	--	46	159	--	--	W	W	4	16
Alaska	--	--	--	--	--	--	W	W	--	--
Arizona	--	--	--	--	--	--	W	W	210	769
Arkansas	W	W	W	W	--	--	W	W	--	--
California	1,421	7,154	W	W	W	W	149	638	W	W
Colorado	W	W	--	--	--	--	W	W	--	--
Connecticut	--	--	--	--	--	--	--	--	--	--
Delaware	--	--	--	--	--	--	--	--	--	--
Florida	W	W	--	--	--	--	148	1,430	--	--
Georgia	W	W	W	W	--	--	W	W	--	--
Hawaii	--	--	--	--	--	--	(1)	1	--	--
Idaho	46	184	--	--	--	--	31	123	--	--
Illinois	904	2,450	710	2,537	W	W	W	W	--	--
Indiana	--	--	W	W	--	--	--	--	--	--
Iowa	--	--	--	--	--	--	W	W	--	--
Kansas	--	--	--	--	--	--	--	--	--	--
Kentucky	--	--	--	--	--	--	11	54	--	--
Louisiana	W	W	W	W	--	--	125	750	--	--
Maine	--	--	--	--	--	--	--	--	--	--
Maryland	--	--	--	--	--	--	--	--	--	--
Massachusetts	--	--	W	W	--	--	W	W	--	--
Michigan	122	359	2,889	7,401	--	--	W	W	W	W
Minnesota	W	W	--	--	--	--	--	--	--	--
Mississippi	--	--	W	W	--	--	--	--	--	--
Missouri	707	2,298	94	353	W	W	W	242	W	W
Montana	--	--	--	--	--	--	--	--	--	--
Nebraska	--	--	--	--	--	--	--	--	--	--
Nevada	W	W	W	W	--	--	--	--	W	W
New Hampshire	--	--	--	--	--	--	--	--	--	--
New Jersey	2,118	9,798	808	3,900	W	W	116	776	W	W
New Mexico	--	--	--	--	--	--	--	--	--	--
New York	--	--	W	W	--	--	--	--	--	--
North Carolina	W	W	--	--	--	--	W	W	W	W
North Dakota	--	--	--	--	--	--	--	--	--	--
Ohio	--	--	225	1,378	--	--	W	W	W	W
Oklahoma	W	W	W	W	W	W	W	W	--	--
Oregon	--	--	--	--	--	--	--	--	--	--
Pennsylvania	W	W	W	W	W	W	W	W	W	W
Rhode Island	--	--	W	W	--	--	W	W	--	--
South Carolina	W	W	W	W	--	--	28	146	W	W
South Dakota	--	--	--	--	--	--	--	--	--	--
Tennessee	304	1,413	217	689	W	W	W	W	W	W
Texas	438	W	119	427	--	--	135	382	W	W
Utah	--	--	W	W	--	--	W	W	--	--
Vermont	--	--	--	--	--	--	--	--	--	--
Virginia	W	W	--	--	--	--	W	W	W	W
Washington	W	95	--	--	--	--	--	--	--	--
West Virginia	W	W	W	W	W	W	W	W	W	W
Wisconsin	W	W	W	W	--	--	W	W	--	--
Wyoming	--	--	--	--	--	--	--	--	--	--
Undistributed	4,099	17,732	2,335	8,698	359	1,152	454	1,589	790	2,428
Total [2]	10,158	41,485	7,446	25,540	359	1,152	1,195	6,133	1,005	3,214
Puerto Rico [e p]	--	--	--	--	--	--	--	--	--	--

See footnotes at end of table.

Table 4.—Sand and gravel sold or used by producers in the United States in 1973, by State, use, and class of operation—Continued

(Thousand short tons and thousand dollars)

State	Sand, industrial (commercial)—Continued									
	Engine		Filtration		Oil (hydrofrac)		Other		Ground sand	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	W	W	--	--	--	--	W	W	W	W
Alaska	--	--	--	--	--	--	--	--	--	--
Arizona	--	--	W	W	W	W	W	W	--	--
Arkansas	--	--	W	W	--	--	--	--	W	W
California	51	186	W	W	W	W	W	W	153	721
Colorado	W	W	W	W	W	W	--	--	--	--
Connecticut	--	--	--	--	--	--	W	W	--	--
Delaware	--	--	--	--	--	--	--	--	--	--
Florida	9	W	56	W	--	--	W	W	56	82
Georgia	W	W	W	W	--	--	W	W	--	--
Hawaii	--	--	--	--	--	--	--	--	--	--
Idaho	--	--	1	3	--	--	15	19	--	--
Illinois	--	--	--	--	W	W	W	W	W	W
Indiana	--	--	--	--	--	--	W	W	--	--
Iowa	--	--	--	--	--	--	W	W	W	W
Kansas	--	--	--	--	--	--	W	W	--	--
Kentucky	--	--	--	--	--	--	W	W	5	35
Louisiana	--	--	--	--	--	--	--	--	--	--
Maine	W	5	--	--	--	--	W	W	--	--
Maryland	--	--	--	--	--	--	--	--	W	W
Massachusetts	W	W	--	--	--	--	W	W	16	20
Michigan	297	720	--	--	--	--	564	893	W	W
Minnesota	--	--	--	--	--	--	--	--	W	W
Mississippi	--	--	--	--	--	--	--	--	--	--
Missouri	W	W	--	--	--	--	W	W	W	W
Montana	--	--	--	--	--	--	7	10	--	--
Nebraska	--	--	--	--	--	--	W	W	--	--
Nevada	--	--	--	--	--	--	W	W	2	5
New Hampshire	--	--	--	--	--	--	--	--	--	--
New Jersey	17	61	W	W	--	--	299	1,085	W	2,983
New Mexico	--	--	--	--	--	--	--	--	--	--
New York	43	89	W	W	--	--	--	--	W	W
North Carolina	--	--	W	W	--	--	W	W	--	--
North Dakota	--	--	--	--	--	--	--	--	--	--
Ohio	W	W	W	W	W	W	W	W	W	W
Oklahoma	--	--	--	--	W	W	W	W	W	W
Oregon	W	W	--	--	--	--	69	137	--	--
Pennsylvania	W	W	W	W	W	W	W	W	W	W
Rhode Island	--	--	W	W	--	--	--	--	--	--
South Carolina	W	W	W	W	--	--	W	W	W	W
South Dakota	--	--	--	--	--	--	--	--	--	--
Tennessee	W	W	--	--	W	W	143	369	W	W
Texas	W	W	W	W	W	W	84	338	W	W
Utah	W	W	--	--	--	--	W	W	W	W
Vermont	W	W	--	--	--	--	--	--	--	--
Virginia	--	--	--	--	--	--	W	W	213	W
Washington	--	--	--	--	--	--	--	--	--	--
West Virginia	W	W	W	W	--	--	W	W	W	W
Wisconsin	W	W	W	W	--	--	W	W	155	536
Wyoming	--	--	--	--	--	--	--	--	--	--
Undistributed	418	982	226	1,366	352	1,773	1,568	6,089	3,993	14,036
Total [2]	835	2,042	283	1,368	352	1,773	2,748	8,940	4,593	18,418
Puerto Rico [e] [p]	--	--	--	--	--	--	--	--	--	--

See footnote at end of table.

Table 4.—Sand and gravel sold or used by producers in the United States in 1973, by State, use, and class of operation—Continued

(Thousand short tons and thousand dollars)

State	Gravel, construction							
	Building				Paving			
	Commercial		Government-and-contractor		Commercial		Government-and-contractor	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	1,577	2,427	--	--	2,918	4,578	4	6
Alaska	815	1,820	10	53	1,256	2,076	7,363	9,020
Arizona	8,849	9,918	58	55	5,724	8,049	1,993	4,420
Arkansas	2,435	4,694	50	25	2,476	4,709	993	747
California	21,107	32,662	1	2	27,019	39,383	6,591	12,909
Colorado	4,829	8,736	722	1,230	11,425	14,482	4,675	5,723
Connecticut	925	1,908	--	--	1,489	2,692	220	609
Delaware	117	217	--	--	W	W	--	--
Florida	W	W	--	--	W	W	47	49
Georgia	32	90	--	--	365	1,044	--	--
Hawaii	W	W	--	--	W	W	--	--
Idaho	1,250	1,965	144	86	2,535	3,364	2,109	1,949
Illinois	7,675	10,596	--	--	11,320	17,701	463	449
Indiana	4,575	6,541	1	1	7,519	10,799	597	513
Iowa	1,503	2,901	315	158	6,211	7,528	663	559
Kansas	469	659	75	63	1,099	1,114	1,088	839
Kentucky	934	1,312	--	--	1,123	1,562	108	146
Louisiana	4,381	7,772	--	--	2,843	4,112	--	--
Maine	717	925	10	5	959	1,178	8,280	4,863
Maryland	3,595	9,474	--	--	384	594	92	66
Massachusetts	4,310	8,067	77	195	2,456	3,566	890	1,870
Michigan	8,478	13,571	--	--	19,035	21,930	2,923	2,207
Minnesota	4,526	8,106	2	2	14,799	13,936	3,442	2,330
Mississippi	3,195	4,423	73	204	5,662	7,438	19	11
Missouri	1,613	2,516	--	--	999	1,095	18	12
Montana	588	918	73	62	1,083	951	8,151	9,763
Nebraska	1,356	1,582	37	30	5,665	7,241	591	484
Nevada	1,613	2,527	12	16	3,877	4,706	3,105	1,677
New Hampshire	763	1,514	--	--	1,563	2,630	587	136
New Jersey	1,876	4,129	--	--	1,437	2,647	4	6
New Mexico	1,838	2,511	170	178	3,005	4,864	1,107	2,307
New York	5,526	9,917	2	1	3,463	5,787	1,002	438
North Carolina	1,408	3,015	--	--	2,438	3,265	385	308
North Dakota	611	1,252	131	131	2,586	2,211	1,247	906
Ohio	9,377	14,446	--	--	14,951	22,578	125	115
Oklahoma	419	759	--	--	195	264	90	93
Oregon	4,519	6,683	--	--	7,307	11,273	2,614	3,624
Pennsylvania	4,520	8,862	--	--	2,718	5,790	--	--
Rhode Island	542	700	--	--	266	510	16	16
South Carolina	W	W	--	--	W	W	--	--
South Dakota	475	773	288	207	3,590	3,963	6,773	8,543
Tennessee	2,462	3,861	--	--	2,036	2,703	554	262
Texas	9,669	17,863	25	29	5,884	10,553	2,366	2,304
Utah	2,311	2,371	70	78	5,575	6,412	1,612	2,228
Vermont	543	796	--	--	524	510	525	204
Virginia	2,423	6,163	--	--	2,549	5,997	8	3
Washington	4,339	6,217	35	17	6,795	8,129	3,691	3,015
West Virginia	1,118	2,198	--	--	904	1,503	--	--
Wisconsin	5,242	6,524	92	47	11,366	12,002	7,531	7,079
Wyoming	559	960	135	147	1,551	1,694	1,347	3,163
Undistributed	2,171	5,367	--	--	2,301	2,319	--	--
Total [2]	154,174	253,208	2,608	3,021	223,248	303,431	86,007	95,969
Puerto Rico [e p]	2,011	7,280	--	--	849	3,004	--	--

See footnotes at end of table.

Table 4.—Sand and gravel sold or used by producers in the United States in 1973, by State, use, and class of operation—Continued

(Thousand short tons and thousand dollars)

State	Gravel, construction—Continued											
	Railroad ballast (commercial)		Fill				Other				Gravel miscellaneous (commercial)	
			Commercial		Government-and-contractor		Commercial		Government-and-contractor			
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	W	W	249	149	--	--	313	354	--	--	138	130
Alaska	132	270	879	776	29	26	269	W	279	102	46	192
Arizona	W	W	2,086	2,099	99	104	522	945	--	--	173	346
Arkansas	W	W	198	180	13	4	20	61	--	--	424	500
California	313	433	1,611	1,381	451	170	1,147	1,735	5,837	1,768	909	1,389
Colorado	242	391	522	454	3,174	1,735	447	697	--	--	859	1,305
Connecticut	--	--	589	419	--	--	111	245	--	--	541	588
Delaware	--	--	W	W	--	--	--	--	--	--	9	W
Florida	W	W	1	13	--	--	--	--	--	--	--	--
Georgia	--	--	25	99	--	--	W	W	--	--	39	78
Hawaii	--	--	W	130	--	--	--	--	--	--	--	--
Idaho	--	--	329	285	510	162	75	76	49	55	141	166
Illinois	W	W	1,526	1,658	2	2	250	335	--	--	428	609
Indiana	W	W	1,196	1,056	3	2	234	318	31	15	366	422
Iowa	31	W	331	366	2	1	823	1,090	125	225	114	160
Kansas	--	--	212	183	28	22	6	10	6	14	284	388
Kentucky	--	--	100	123	--	--	9	W	--	--	49	66
Louisiana	--	--	76	W	--	--	401	483	12	9	W	W
Maine	W	W	294	137	3	1	198	226	289	556	223	226
Maryland	--	--	695	1,305	--	--	W	W	--	--	704	2,171
Massachusetts	W	W	1,500	917	30	19	600	704	2	3	1,221	911
Michigan	W	W	453	383	672	364	351	750	196	154	4,317	3,964
Minnesota	94	103	1,135	625	463	330	159	197	186	204	754	726
Mississippi	W	W	566	316	--	--	30	30	--	--	186	156
Missouri	--	--	265	131	28	21	62	123	8	12	516	999
Montana	W	W	205	143	355	268	130	191	98	51	58	70
Nebraska	237	254	70	61	187	363	240	229	379	625	630	629
Nevada	W	W	355	291	15	15	W	W	651	326	66	155
New Hampshire	W	W	293	142	--	--	102	188	--	--	385	350
New Jersey	--	--	767	660	--	--	153	317	--	--	537	1,239
New Mexico	--	--	153	116	1,540	1,302	129	212	10	13	34	49
New York	1	2	1,553	1,207	387	86	149	252	38	32	988	981
North Carolina	W	W	129	106	15	15	W	W	52	39	377	426
North Dakota	--	--	203	187	164	79	37	105	7	2	40	30
Ohio	W	W	2,561	2,174	9	14	400	535	--	--	1,029	1,555
Oklahoma	--	--	78	47	--	--	11	27	--	--	17	25
Oregon	13	19	1,964	1,681	48	35	775	1,070	51	27	707	1,084
Pennsylvania	W	W	462	463	--	--	W	W	--	--	365	635
Rhode Island	--	--	W	W	--	--	W	W	--	--	144	112
South Carolina	--	--	W	W	--	--	--	--	--	--	W	W
South Dakota	--	--	311	220	112	56	18	W	254	166	400	470
Tennessee	W	W	301	359	--	--	42	93	--	--	W	W
Texas	W	W	332	195	19	10	W	W	5	15	708	531
Utah	W	W	502	269	1,312	735	617	552	75	108	73	79
Vermont	W	W	123	67	--	--	W	W	--	--	56	82
Virginia	W	W	277	321	--	--	W	W	--	--	94	154
Washington	107	136	2,977	1,821	1,335	272	671	1,227	111	50	855	1,143
West Virginia	--	--	W	W	--	--	--	--	--	--	--	--
Wisconsin	W	W	1,158	633	320	93	705	708	18	7	942	984
Wyoming	90	67	138	131	2	2	W	W	6	3	244	248
Undistributed	1,484	1,988	487	401	--	--	729	1,488	--	--	345	356
Total[2]	2,743	3,663	30,237	24,883	11,329	6,306	10,938	15,574	8,777	4,583	21,537	26,880
Puerto Rico[e p]	--	--	259	324	--	--	--	--	--	--	--	--

[e] Estimate. [p] Preliminary. W Withheld to avoid disclosing individual company confidential data, included with "Undistributed."

[1] Less than ½ unit.

[2] Data may not add to totals shown because of independent rounding.

[3] Includes unspecified.

Table 5.—Sand and gravel sold or used by Government-and-contractor producers in the United States, by use[1]

(Thousand short tons and thousand dollars)

Year	Sand: Building Quantity	Building Value	Paving Quantity	Paving Value	Fill Quantity	Fill Value	Other Quantity	Other Value
1969	1,016	1,320	32,123	28,317	6,123	3,745	2,168	1,014
1970	r 833	1,058	43,130	41,965	5,234	2,195	1,632	834
1971	1,434	1,489	30,334	r 32,035	4,086	1,145	2,298	1,360
1972	2,976	1,777	20,218	19,845	3,996	1,581	2,212	1,121
1973	246	369	21,529	30,050	4,192	2,938	2,137	1,576

Year	Gravel: Building Quantity	Building Value	Paving Quantity	Paving Value	Fill Quantity	Fill Value	Other Quantity	Other Value	Total Government-and-contractor sand and gravel[2] Quantity	Value
1969	1,976	2,522	133,127	116,774	28,240	19,481	1,423	890	r 206,196	174,070
1970	1,839	1,516	141,316	137,579	16,144	6,990	1,323	1,009	211,454	193,145
1971	2,857	2,667	96,453	98,410	7,723	2,981	2,033	1,143	147,212	141,229
1972	2,562	2,148	79,054	79,434	14,674	4,292	1,895	1,371	127,587	111,569
1973	2,608	3,021	86,007	95,969	11,329	6,306	8,777	4,583	136,824	144,811

r Revised.
[1] Excludes American Samoa, the Canal Zone, and Puerto Rico.
[2] Data may not add to totals shown because of independent rounding.

Table 6.—Sand and gravel sold or used by Government-and-contractor producers in the United States, by type of producer[1]

(Thousand short tons and thousand dollars)

Type of producer	1969 Quantity	1969 Value	1970 Quantity	1970 Value	1971 Quantity	1971 Value	1972 Quantity	1972 Value	1973 Quantity	1973 Value
Construction and maintenance crews	65,786	45,691	67,238	39,446	58,820	30,428	62,072	36,013	60,168	45,085
Contractor	140,403	128,377	144,214	153,699	88,395	110,800	65,515	75,556	76,654	99,726
Total[2]	206,189	174,070	211,454	193,145	147,212	141,229	127,587	111,569	136,824	144,811
State	122,484	108,414	136,800	134,482	79,213	85,347	65,561	65,244	70,413	89,696
Counties	52,547	39,429	58,180	37,159	56,175	38,176	52,228	35,154	52,270	40,055
Municipalities	3,784	4,466	3,285	3,125	2,266	2,013	2,658	2,546	2,716	2,860
Federal agencies	27,374	21,761	13,189	18,379	9,558	15,693	7,141	8,624	11,424	12,199
Total[2]	206,189	174,070	211,454	193,145	147,212	141,229	127,587	111,569	136,824	144,811

[1] Excludes American Samoa, the Canal Zone, and Puerto Rico.
[2] Data may not add to totals shown because of independent rounding.

Table 7.—Sand and gravel sold or used by producers in the United States by class of operation and degree of preparation[1][2]

(Thousand short tons and thousand dollars)

	1972 Quantity	1972 Value	1973 Quantity	1973 Value
Commercial operations:				
Prepared	r 717,193	r 1,038,358	764,554	1,151,766
Unprepared	69,544	50,774	82,251	62,793
Total	r 786,737	r 1,089,132	846,805	1,214,559
Government-and-contractor operations:				
Prepared	106,986	98,679	117,372	134,624
Unprepared	20,601	12,890	19,452	10,187
Total	127,587	111,569	136,824	144,811
Grand total	r 914,324	r 1,200,701	983,629	1,359,370

r Revised.
[1] Data may not add to totals shown because of independent rounding.
[2] Excludes Puerto Rico.

Table 8.—Number and production of domestic commercial sand and gravel plants, by size of operation [1]

Annual production (short tons)	1972				1973			
	Plants [2]		Production		Plants [2]		Production	
	Number	Percent of total	Thousand short tons	Percent of total	Number	Percent of total	Thousand short tons	Percent of total
Less than 25,000	1,630	30.3	17,541	2.2	1,655	29.1	18,054	2.1
25,000 to 50,000	850	15.8	30,508	3.9	884	15.6	32,244	3.7
50,000 to 100,000	957	17.8	68,788	r 8.7	1,053	18.5	75,822	9.0
100,000 to 200,000	849	15.8	121,304	15.4	904	15.9	129,084	15.2
200,000 to 300,000	400	7.4	97,088	r 12.3	450	7.9	109,976	13.0
300,000 to 400,000	217	4.0	75,157	9.6	230	4.1	79,468	9.4
400,000 to 500,000	134	2.5	59,757	7.6	134	2.4	59,977	7.1
500,000 to 600,000	79	1.5	42,924	5.5	78	1.4	42,472	5.0
600,000 to 700,000	r 70	1.3	r 45,374	r 5.8	79	1.4	51,306	6.1
700,000 to 800,000	56	1.0	41,860	5.3	48	.8	35,345	4.2
800,000 to 900,000	26	.5	22,310	2.8	42	.7	35,708	4.2
900,000 to 1,000,000	27	.5	25,666	3.3	24	.4	22,635	2.7
1,000,000 and over	r 89	1.6	r 138,461	r 17.6	100	1.8	154,713	18.3
Total [3]	r 5,384	100.0	r 786,737	100.0	5,681	100.0	846,805	100.0

r Revised.
[1] Excludes Puerto Rico.
[2] Includes a few companies operating more than one plant but not submitting returns for individual plants.
[3] Data may not add to totals shown because of independent rounding.

Table 9.—Sand and gravel sold or used in the United States, by class of operation and method of transportation [1] [2]

	1972		1973	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Commercial:				
Truck	r 709,128	77	768,040	78
Rail	r 44,364	5	41,641	4
Waterway	27,050	3	32,686	3
Unspecified	6,195	1	4,438	1
Total commercial	r 786,737	86	846,805	86
Government-and-contractor: Truck [3]	127,587	14	136,824	14
Grand total	r 914,324	100	983,629	100

r Revised.
[1] Data may not add to totals shown because of independent rounding.
[2] Excludes Puerto Rico.
[3] Entire output of Government-and-contractor operations assumed to be moved by truck.

Table 10.—Ground sand sold or used by producers in the United States,[1] [2] by use

(Thousand short tons and thousand dollars)

Use	1972		1973	
	Quantity	Value	Quantity	Value
Abrasives	204	1,938	235	2,142
Chemicals	141	568	76	508
Enamel	52	525	42	406
Filler	172	1,648	164	1,707
Foundry use	2,318	6,288	2,928	6,917
Glass	1,042	5,696	726	3,679
Pottery, porcelain, tile	221	2,261	169	1,706
Unspecified	362	2,623	253	1,353
Total	4,512	[3] 21,546	4,593	18,418

[1] Includes Alabama, Arkansas, California, Florida, Georgia (1972), Idaho (1972), Illinois, Indiana (1972), Iowa, Kansas (1972), Kentucky, Maryland (1973), Massachusetts, Michigan, Minnesota, Missouri, Nevada, New Jersey, New York, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee, Texas, Utah, Virginia, West Virginia, and Wisconsin.
[2] Excludes Puerto Rico.
[3] Data does not add to total shown because of independent rounding.

Table 11.—U.S. imports for consumption of sand and gravel, by class
(Thousand short tons and thousand dollars)

Year	Glass sand [1]		Sand, n.s.p.f., crude or manufactured, and gravel		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1971	48	243	667	984	715	1,227
1972	49	201	712	1,178	761	1,379
1973	48	340	752	1,236	800	1,576

[1] Classification reads: Sands containing 95% or more silica and not more than 0.6% oxide of iron and suitable for manufacturing glass.

Silicon

By E. Shekarchi [1]

The energy shortage had a severe effect on the ferrosilicon industry in 1973. From the beginning of the second quarter the gap between the supply of ferrosilicon and demand began to narrow. Supplies of silicon metal and ferrosilicon products became increasingly tight throughout the year and by yearend were allocated on the basis of the customer's previous order pattern.

Domestic plant expansions and/or modernizations continued as ferroalloy producers moved toward plant specialization and compliance with federal and local government antipollution standards which are to become effective by 1975. In the world market, all grades of ferrosilicon and silicon metal appeared to be in short supply. Prices of silicon metal and ferrosilicon on the international market were substantially higher than the controlled prices in the United States.

DOMESTIC PRODUCTION

Production and shipments of ferrosilicon, and silicon metal and alloys, paralleling those of steel and aluminum, increased 8% and 20% respectively compared with 1972 figures. Yearend stocks had decreased by 65% when compared with those of 1972. With regard to individual ferrosilicon grades, production of nominal 50% ferrosilicon increased 3.6% whereas production of ferrosilicon containing 71% to 80% silicon increased 16.7%. Production of silicon metal increased 14.7% over that of the previous year. Ferrosilicon and silicon metals were produced at 27 plants by 14 companies as shown in table 2.

Northwest Alloy, Inc., a subsidiary of Aluminum Company of America (Alcoa), received final permission from the State of Washington Department of Ecology to start construction on a $50 million magnesium and silicon metal plant at Addy, Wash. Originally, construction of the Addy plant was to begin in April 1973, with completion scheduled for early 1975; however, after the delayed start, no new opening date had been set. Most of the plant's annual 40,000-ton silicon production is to be used by Alcoa although some will be available to other metals producers. The Addy plant will be the first of its kind in the United States to employ the megatherm (electrothermal) process with dolomite as raw material. This process, in operation at Marignac, France, since 1964, involves the reduction of calcium dolomite by ferrosilicon at a temperature in excess of 1,500° C.

[1] Physical scientist, Division of Ferrous Metals—Mineral Supply.

Table 1.—Production, shipments, and stocks of silvery pig iron, ferrosilicon, and silicon metal in 1973
(Short tons, gross weight)

Alloy	Silicon content (percent)	Producers' stocks as of Dec. 31, 1972 r	Production	Shipments	Producers' stocks as of Dec. 31, 1973
Silvery pig iron	5–24	W	W	W	W
Ferrosilicon (includes briquets)	25–55	57,253	509,897	492,717	17,127
Do	56–70	5,322	58,818	60,126	2,400
Do	71–80	30,073	128,299	155,899	9,740
Do	81–95	1,059	3,785	4,976	41
Silicon metal (excludes semiconductor grades)	96–99	7,451	133,527	119,168	4,686
Miscellaneous silicon alloys (exclusive of silicomanganese)	--	12,203	81,805	83,932	5,239
Other silicon alloys and products	--	2,844	9,497	8,646	2,005

r Revised. W Withheld to avoid disclosing individual company confidential data.

Reynolds Metals Co. announced in October plans to more than double the capacity of its silicon plant at Sheffield, Ala. Expansion of the plant, which now produces 7,000 tons of silicon for aluminum casting, is to begin in the fall of 1974 with completion expected by March 1975. Transformer capacity of the new furnace is to be about 1,500 kilovolt-amperes (kVA).

Ohio Ferro-Alloys Corp. announced plans to build in 1974 a new 46,000 kVA electric furnace at the company's Philo plant in Philo, Ohio. The new covered furnace will be installed in an existing building and will be equipped with a modular-constructed bag-house type collector. The company expects new production to begin early in 1975. The total cost of the project was estimated at $4 million.

Table 2.—Producers of silicon alloys and/or silicon metal in the United States in 1973

Producers	Plant location	Product
Airco, Inc., Airco Alloys and Carbide Division	Calvert City, Ky	FeSi.
Do	Charleston, S.C	Do.
Do	Mobile, Ala	Do.
Do	Niagara Falls, N.Y	Do.
Alabama Metallurgical Corp	Selma, Ala	FeSi,Si.
Chromium Mining & Smelting Corp	Woodstock, Tenn	FeSi.
Foote Mineral Co	Graham, W. Va	Do.
Do	Keokuk, Iowa	Silvery iron.
Do	Wenatchee, Wash	FeSi,Si.
Hanna Furnace Corp	Buffalo, N.Y	Silvery iron.
Hanna Nickel Smelting Co	Riddle, Oreg	FeSi.
Interlake Steel Corp	Beverly, Ohio	FeSi,Si.
National Metallurgical Corp	Springfield, Oreg	Si.
Ohio Ferro-Alloys Corp	Brilliant, Ohio	FeSi,Si.
Do	Philo, Ohio	Do.
Do	Powhatan Point, Ohio	Do.
Do	Tacoma, Wash	Do.
Reynolds Metals Co	Sheffield, Ala	Si.
Tennessee Alloys Corp	Bridgeport, Ala	FeSi.
Tennessee Metallurgical Corp	Kimble, Tenn	Do.
Union Carbide Corp. Ferroalloys Division	Alloy, W.Va	FeSi,Si.
Do	Ashtabula, Ohio	FeSi.
Do	Marietta, Ohio	Do.
Do	Portland, Oreg	Do.
Do	Sheffield, Ala	Do.
Woodward Corp	Woodward, Ala	Do.
Do	Rockwood, Tenn	Do.

CONSUMPTION AND USES

Silicon metal continued to be used mainly as an additive to aluminum and for the production of silicon chemicals. It was also used in iron and steel, high-temperature alloys, superalloys, copper base alloys and electrical contact materials. Ferrosilicon was used primarily for deoxidizing steel, and producing silicon alloy steels and cast-irons. The greater part of silvery pig iron was consumed by iron foundries and a sizable quantity was used in the manufacture of steel.

World demand for high-purity silicon increased significantly in 1973 and most consumers felt the pinch of the short supply. In the United States large producers and consumers of polycrystalline and high purity silicon (Texas Instruments, Inc., Motorola Inc., Fairchild Camera & Instruments, Corp., and Dow Corning Corp.) operated at full capacity. Dow Corning announced plans to increase its polycrystalline capacity by another 40% over its 1973 expansion. The new facilities at the company's Hemlock, Mich., plant were scheduled for completion in the latter part of 1975. Monsanto Chemical Co., another polycrystalline silicon producer, planned by 1975 to expand its plant in Missouri.

Demand for polycrystalline silicon in the electronics industry increased with the growing market for personal calculators, and the use of solid state devices in automobiles and in sales and cash registers.

Among more recent developments, polycrystalline silicon furnace tubes and fixtures used in semiconductor processing were found to be much more resistant to high temperatures and sudden temperature changes than those made of quartz.

Table 3.—Consumption, by major end uses and stocks of silicon alloys and metal in the United States in 1973

(Short tons)

	Silicon content percent						
	Silvery pig iron	Ferrosilicon [1]				Silicon metal	Miscellaneous silicon alloys [2]
	5–24	25–55	56–70	71–80	81–95	96–99	
Steel:							
Carbon	3,351	118,008	4,375	42,265	772	1,087	13,450
Stainless and heat resisting	--	19,940	284	9,966	214	98	462
Full alloy	1,073	39,834	1,864	12,064	1,190	1,522	1,725
High-strength low-alloy	2,184	9,872	(3)	2,332	141	(3)	1,262
Electric	--	350	(3)	27,249	(3)	(3)	--
Tool	--	2,596	(4)	976	(4)	327	124
Cast irons	276,266	252,227	9,396	39,831	7,193	85	120,375
Superalloys	--	297	--	12	189	84	4
Alloys (exclude alloy steels and superalloys)	243	3,332	8	822	12,015	64,662	8,340
Miscellaneous and unspecified	3,857	5,391	8	618	142	37,838	1,536
Total	286,974	451,847	15,930	136,135	21,856	105,703	147,278
Consumers stocks, Dec. 31, 1973	57,666	46,245	1,371	13,420	2,860	13,061	10,790

[1] Includes briquets.
[2] Includes magnesium-ferrosilicon and other silicon alloys.
[3] Included with "Full alloy steel."
[4] Included with "Miscellaneous and unspecified."

PRICES

The prices of ferrosilicon and silicon metals were increased in the second and fourth quarter of the year as allowed by Phase IV price stabilization rules. The f.o.b. price of 50% ferrosilicon increased from 15 cents per pound in 1972 to 18.5 cents per pound contained silicon, bulk, carload lots in 1973. Metallurgical-grade silicon, 98% minimum silicon, 0.35% maximum iron increased from 25.4 in 1972 to 28.4 cents per pound contained silicon in 1973. Amorphous silicon in 50-pound paper bags, 200 mesh, 90% to 95% silicon was increased to $27 per ton in 1973 from $26 per ton in the previous year.

The price increases were attributed to substantially higher costs for scrap iron, metallurgical-grade coal, electric power and to the cost of newly installed devices for environmental control such as bag houses and water purification plants.

FOREIGN TRADE

Exports of ferrosilicon and silicon metal increased 117% in quantity and about 84% in value; major recipients were Sweden, 9,148 tons; Canada, 3,424 tons; and the Netherlands, 833 tons. Twenty countries received shipments ranging from 1 to 100 tons.

The unfavorable trade imbalance in ferrosilicon that was evident in the United States in 1972 continued through 1973, although ferrosilicon imports for consumption leveled off in the fourth quarter. Imports of ferrosilicon and silicon metal for consumption increased 161% in quantity and 130% in value over those of 1972. Major increases in quantity were in the over 60% but less than 80% ferrosilicon category and the not over 99.7% silicon metal category. Total value of imports amounted to $32.9 million in 1973 compared with $14 million in 1972.

Table 4.—U.S. exports of ferrosilicon

Year	Quantity (short tons)	Value (thousands)
1971	25,506	$5,603
1972	7,367	2,196
1973	15,984	4,051

Table 5.—U.S. imports for consumption of ferrosilicon and silicon metal, by grade and country

Grade and country	1971			1972			1973		
	Quantity (short tons)		Value (thousands)	Quantity (short tons)		Value (thousands)	Quantity (short tons)		Value (thousands)
	Gross weight	Silicon content		Gross weight	Silicon content		Gross weight	Silicon content	
Ferrosilicon:									
Over 8% but not over 60% silicon:									
Canada	6,039	987	$419	6,579	1,043	$419	15,875	3,429	$1,137
Denmark	--	--	--	113	51	37	1,051	467	349
France	1,388	624	492	2,553	1,245	936	2,728	1,467	1,056
Germany, West	276	127	75	552	305	226	222	112	95
Japan	3,587	1,687	1,111	2,466	1,174	736	1,319	631	445
Norway	685	304	213	2,205	980	684	1,485	659	471
South Africa, Republic of	--	--	--	--	--	--	1,299	492	104
Spain	--	--	--	57	26	16	--	--	--
Total	11,975	3,729	2,310	14,525	4,824	3,054	23,979	7,257	3,657
Over 60% but not over 80% silicon:									
Belgium-Luxembourg	--	--	--	55	37	23	36	22	15
Brazil	--	--	--	--	--	--	350	263	71
Canada	791	603	215	949	715	240	2,934	2,210	772
Denmark	44	26	17	--	--	--	--	--	--
France	2,836	1,744	1,129	4,538	2,806	1,791	7,968	4,879	3,344
Germany, West	444	270	162	56	35	21	101	67	56
Greece	--	--	--	--	--	--	2,773	2,110	536
Japan	50	38	10	--	--	--	2	1	1
Netherlands	--	--	--	2,894	2,205	433	854	635	156
Norway	2,569	1,919	736	9,159	6,935	1,549	37,818	28,565	6,884
South Africa, Republic of	318	246	63	157	120	34	614	470	152
Spain	--	--	--	--	--	--	771	578	127
Sweden	3,114	2,307	541	4,901	3,632	1,256	15,622	11,599	3,953
Taiwan	28	20	7	--	--	--	--	--	--
Turkey	--	--	--	2,211	1,697	367	--	--	--
U.S.S.R	--	--	--	--	--	--	110	87	60
Yugoslavia	2,224	1,718	539	--	--	--	5,566	4,264	1,237
Total	12,418	8,891	3,419	24,920	18,182	5,714	75,519	55,750	17,364
Over 80% but not over 90% silicon:									
Canada	60	51	18	--	--	--	369	319	39
South Africa, Republic of	14	12	3	--	--	--	27	24	8
Total	74	63	21	--	--	--	396	343	47
Over 90% silicon content:									
France	--	--	--	40	38	12	--	--	--
Norway	--	--	--	115	110	35	--	--	--
Sweden	--	--	--	--	--	--	39	38	19
Total	--	--	--	155	148	47	39	38	19
Grand total	24,467	12,683	5,750	39,600	23,154	8,815	99,933	63,388	21,087
Silicon metal:									
Not over 99.7% silicon:									
Belgium-Luxembourg	--	--	--	--	--	--	92	91	44
Canada	174	173	74	790	780	385	259	256	112
France	--	--	--	121	120	46	1,125	1,099	499
Germany, West	--	--	--	(1)	(1)	(1)	18	17	11
Italy	--	--	--	1,681	1,657	584	--	--	--
Japan	--	--	--	--	--	--	248	244	107
Netherlands	--	--	--	--	--	--	816	808	440
Norway	22	21	8	r 1,306	r 1,281	r 413	2,784	2,747	1,156
Spain	--	--	--	--	--	--	55	54	37
Sweden	--	--	--	--	--	--	20	19	9
Switzerland	--	--	--	--	--	--	384	379	207
United Kingdom	2	1	2	276	272	97	755	748	398
Yugoslavia	--	--	--	61	55	18	1,383	1,126	489
Total	198	195	84	r 4,235	r 4,165	r 1,543	7,939	7,588	3,509

See footnotes at end of table.

Table 5.—U.S. imports for consumption of ferrosilicon and silicon metal, by grade and country—Continued

Grade and country	1971 Quantity (short tons) Gross weight	1971 Silicon content	1971 Value (thousands)	1972 Quantity (short tons) Gross weight	1972 Silicon content	1972 Value (thousands)	1973 Quantity (short tons) Gross weight	1973 Silicon content	1973 Value (thousands)
Silicon metal—Continued:									
Over 99.7% silicon:									
Belgium-Luxembourg	(1)	(1)	4	(1)	(1)	38	1	1	142
Canada	--	--	--	1	1	2	21	21	14
Denmark	(1)	(1)	44	(1)	(1)	73	1	1	79
France	2	2	92	1	1	35	108	108	125
Germany, West	12	12	1,173	53	53	3,318	81	81	7,012
Japan	17	17	607	5	5	450	12	12	806
Netherlands	--	--	--	--	--	--	220	220	115
United Kingdom	(1)	(1)	(1)	(1)	(1)	7	(1)	(1)	11
Total	31	31	1,920	60	60	3,923	444	444	8,304
Grand total	229	226	2,004	r 4,295	r 4,225	r 5,466	8,383	8,032	11,813

r Revised.
1 Less than ½ unit.

WORLD REVIEW

India.—The two major ferrosilicon producers in India were the public sector firm, Mysore Iron and Steel, Ltd., at Bhadravati and the private sector firm, Indian Metals and Ferroalloys, Ltd., at Bhubaneshwar, Orissa. Output of ferrosilicon and silicon metal during 1973 was about 35,000 tons, a 75% increase over 1972 production of 20,000 tons. Two new small companies which contributed about 5,000 tons to the 1973 production were Industrial Development Corp., Ltd., with a plant located in Orissa and Ferroalloy Corp. Ltd., with a plant at Andhra Pradesh.

In 1972 India, for the first time, exported ferrosilicon: 3,000 tons to Sweden and smaller tonnages to New Zealand, Bangladesh, and Sri Lanka.

Italy.—Construction work on a new plant in Sicily, which will produce 148,000 tons per year of ferrosilicon, silicon metal, and ferrochrome, continued in 1973. Production is to begin in mid-1974. It was reported that Montecatini Edison S.p.A. is to build a new plant for the production of silicon metal at Sinigo, Italy. Cost of the plant was estimated at $8.6 million and reportedly production will start in 1975.

Japan.—Production of ferrosilicon and silicon metal in 1973 was reduced 20% due to a severe fuel crisis and several plant shutdowns caused by furnace explosions To overcome the shortage, Japan's steel industry imported 17,000 tons of ferrosilicon from Sweden, Norway, and Yugoslavia. Unless the energy crisis diminishes, Japan is expected to import about 24,000 tons of ferrosilicon in 1974.

Nippon Denko Co., which produced silicon metal in plants at Minamata and Koriyama, announced in 1973 plans to expand production capacity from 20,000 to 28,000 tons per year. The decision was based on Japan's increased aluminum ingot production which consumed most of the silicon metal output.

South Africa, Republic of.—Aluminum Co. of Canada (Alcan) and Foote Mineral Co. of the United States joined with the mining and engineering subsidiary of African Oxygen Co. of South Africa to form a new company—Silicon Smelters (Pty) Ltd. The three partners will have equal shares in the new company. Silicon Smelters will operate a mine and a plant for the manufacture of silicon metal at Pietersburg in northern Transvaal, about 200 miles north of Johannesburg. The plant with an annual capacity of 30,000 tons of silicon metal will cost about $25 million and is expected to go into production in 1975.

Yugoslavia.—The Yugoslavian Economic Organization's (YEO) Electrobosna Co. in Jajce, central Yugoslavia, commissioned its fifth ferrosilicon electric furnace in the latter part of April 1973. The new furnace has a 480 kVA transformer and will increase the company's ferrosilicon productive capacity by 40%. YEO's Jugobrom Company at Jegunovce, in southern Yugoslavia, was constructing a new 30,000-ton capacity ferrosilicon plant that is to begin production in 1976. Most of the expansion programs were aimed at export markets in Europe.

Total production of ferrosilicon and silicon metals and alloys by Yugoslavia was about 65,000 tons in 1973.

Silver

By J. R. Welch [1]

The domestic mine output of silver was 37.8 million troy ounces, nearly 2% higher than in 1972. Imports exceeded exports by 119.5 million ounces, and consumption, including coinage increased 28% to 196.9 million ounces.

There were several significant events in the silver market in 1973. The price of silver set new highs, and industrial consumption, excluding coinage, was greater than in any other single year. The use of silver for all industrial purposes increased sharply, except for use in batteries. Silver used in the manufacture of commemorative medals, embossed bars, and small ingots increased to 21.9 million ounces, 92% more than in 1972. Part of the increase was attributed to coin blanks made for the Canadian Government. Industry stocks (exclusive of trading firms) continued to decline, ending the year at 38.4 million ounces compared with 51.9 million ounces at yearend 1972. Trading volume on the New York Commodity Exchange (COMEX) amounted to 12 billion ounces during 1973, a 52% increase over that traded in 1972. During the year, trading on the Chicago Board of Trade increased to 8 billion ounces, more than double the volume traded in 1972. COMEX stocks decreased from 77.6 million ounces at the end of 1972 to 64.3 million ounces at the end of 1973, and during the same time period, Chicago Board of Trade stocks increased from 22.8 million ounces at the end of 1972 to 27.4 million ounces at the end of 1973.

[1] Physical scientist, Division of Nonferrous Metals—Mineral Supply.

Table 1.—Salient silver statistics

	1969	1970	1971	1972	1973
United States:					
Mine production ______thousand troy ounces__	41,906	45,006	41,564	37,233	37,827
Value _______________________thousands__	$75,040	$79,697	$64,258	$62,737	$96,762
Ore (dry and siliceous) produced:					
Gold ore __________thousand short tons__	2,002	r 2,086	r 1,872	r 1,579	[1] 3,817
Gold-silver ore ____________________do____	216	r 214	167	r 173	124
Silver ore _______________________do____	755	r 720	r 683	r 564	593
Percentage derived from:					
Dry and siliceous ores ________________	36	r 37	37	r 31	30
Base metal ores ______________________	64	r 63	63	r 69	70
Refinery production [2] __thousand troy ounces__	43,769	49,451	37,242	38,366	36,494
Exports [3] ____________________________do____	88,909	27,614	12,224	29,657	11,215
Imports, general [3] ____________________do____	71,876	62,300	57,962	65,406	130,681
Stocks Dec. 31:					
Treasury [4] ________million troy ounces__	104	25	48	46	45
Industry [5] _______thousand troy ounces__	198,790	210,150	185,335	r 152,255	130,111
Consumption:					
Industry and the arts ____________do____	141,544	128,404	129,146	151,063	195,941
Coinage __________________________do____	19,407	709	2,474	2,284	920
Price [6] ____________________per troy ounce__	$1.790+	$1.771—	$1.542—	$1.685—	$2.558—
World:					
Production ___________thousand troy ounces__	295,718	300,991	r 294,713	294,159	305,916
Consumption: [7]					
Industry and the arts ____________do____	r 350,600	r 338,900	r 351,400	r 391,300	463,000
Coinage __________________________do____	40,000	r 26,900	r 27,200	r 36,500	20,000

r Revised.
[1] Includes tonnages from which silver is heap leached and vat leached.
[2] From domestic ores.
[3] Excludes coinage.
[4] Excludes silver in silver dollars.
[5] Includes silver in COMEX warehouses and silver registered in Chicago Board of Trade.
[6] Average New York price—Source: Handy & Harman.
[7] Free world only—Source: Handy & Harman.

During the year, the price of silver fluctuated widely and price gains were extensive. A low of 196.2 cents per troy ounce was established on January 24; a high of 328.0 cents per ounce was established on December 27, a difference of 131.8 cents per ounce between the two extremes. As industrial consumption was greater than in any other single year, and this fact, together with the reduction of industry stocks, most probably was one cause for the wide price fluctuations. Another reason for the large price rise during the year was the increasing speculative interest and public desire to own silver and other precious metals.

Net imports of silver rose sharply from 35.7 million ounces in 1972 to 119.5 million ounces in 1973. Most of the imports were in the form of refined bullion, a large percentage of which came from Mexico, Canada, Peru, and the United Kingdom.

During 1973, the Government sold, through the General Services Administration (GSA), 2.0 million ounces of fine silver that had been recovered through reclamation activities of the Department of Defense. The Government also released its stock of uncirculated Carson City silver dollars during 1973.

Stocks (including Chicago and New York exchanges) declined to 130.1 million ounces, compared with 152.3 million ounces (revised) at the end of 1972.

Legislation and Government Programs.—Legislation was enacted in October 1973 authorizing the issuance, beginning July 4, 1975, of up to 45 million silver-clad coins honoring the bicentennial of United States independence. The coins will be 40% silver by weight in a three-layer composite of which the outer cladding will be 800 parts silver with 200 parts copper, bonded to a core of approximately 215 parts silver and 785 parts copper. The coin will consist of the dollar, half-dollar, and quarter.

On April 12, 1973, the Office of Emergency Preparedness announced a revised stockpile objective of 21.7 million ounces of silver, 117.8 million ounces less than the inventory and previous objective. Although the excess silver became available for disposal, it could not be sold without congressional approval, and the total amount remained in the stockpile at yearend.

Silver remained eligible for exploration assistance up to 75% of approved costs under a program conducted by the Office of Minerals Exploration (OME) in the U.S. Geological Survey. A few contracts were active in 1973.

DOMESTIC PRODUCTION

Domestic mine production of silver was 37.8 million ounces, about 2% higher than in 1972. A 4-month strike at the Sunshine Mining Co. in Idaho limited the rise in production. Base-metal ores provided 70% of the total silver output, silver ores provided 28% and the remainder came from gold and gold-silver production.

Idaho's silver output in 1973 declined 4% from 1972 and was 36% of the U.S. production. The combined production of Idaho, Arizona, Montana, Colorado, and Utah was 87% of domestic production.

The 25 leading silver producers contributed 84% of the total output. Four of the producers mined silver ores alone while the rest were base-metal producers. Eight mines produced over 1 million ounces of silver each, their combined output equalling 55% of the total domestic production. Domestic mine output provided 19% of the total silver consumption by industry and the arts.

In 1973, a 4-month strike reduced materially the Sunshine Mining Co. production. This mine has been the country's leading silver producer for several years. Hecla Mining Co. produced 3.9 million ounces, 14% less than 1972 production. Contributing to Hecla's lower production was the December 1972 closing of the Mayflower mine, operated under lease in Utah. The average selling price for Hecla's silver in 1973 was 255.8 cents per ounce, up from the 168.5 cents per ounce in 1972. Hecla's Lucky Friday mine produced 176,859 tons of ore assaying 15.49 ounces of silver per ton, 11.14% lead, and 1.22% zinc, compared with 192,020 (revised) tons of ore assaying 14.62 ounces of silver per ton, 10.43% lead, and 1.32% zinc produced in 1972. Ore reserves at yearend amounted to 510,000 tons, compared with 584,000 tons at the beginning of 1973. Sunshine Mining Co. is the operator of the Sunshine unit area, which produces from properties owned by Hecla Mining Co., Sunshine Mining Co., and Silver Dollar Mining Co. Hecla's 33.25% share of the unit area production was 38,769 tons of ore assaying 25.30 ounces of silver per ton, compared with 33,738 tons of ore assaying 27.32 ounces of silver in 1972. Hecla's share of unit area ore reserves at yearend was 267,000 tons, compared with 258,000 (revised) tons at the beginning of the year.

In addition to the Sunshine mine, Hecla owns a 30% interest in production from the Star-Morning mine. Hecla's share of the 1973 production was 79,734 tons assaying 2.79 ounces of silver per ton, 5.18% lead, and 6.68% zinc, compared with 79,079 tons assaying 2.87 ounces of silver per ton, 5.33% lead, and 7.36% zinc in 1972.

The Bunker Hill Co. produced about 2.6 million ounces of silver in 1973, down from 3.8 million ounces produced in 1972. At the Cresent mine, production of silver was down to 595,000 ounces, which reflected declining ore grades in the lower mine levels. Production in 1972 was 1.53 million ounces. Mine development work underway in the Crescent mine in 1974 was expected to determine future production from this mine.

The Anaconda Company reported silver production of 4.26 million ounces during 1973, up from 4.0 million ounces produced in 1972. The company also reported a partnership in Park City Ventures, owned 60% by Anaconda and 40% by the American Smelting and Refining Co. (ASARCO), which will operate a reactivated lead-silver-zinc mine at Park City, Utah, under lease from the United Park City Mines Co. New reserves were developed, and production was expected to begin in 1975 at an estimated annual rate of 1.2 million ounces of silver and substantial quantities of lead and zinc. A second partnership, on a 50–50 basis, is with Anamax Mining Co. in the operation of the Twin Buttes copper mine in Arizona.

ASARCO operated the Galena mine in the Coeur d'Alene district in Idaho under a lease arrangement from the Callahan Mining Corp. Production from this mine in 1973 was 4.2 million ounces of silver, about the same as 1972. ASARCO also announced an expansion program which included the construction of a new electrolytic copper refinery near Amarillo, Tex. The unit, which was to replace an old refinery at Baltimore, Md., was planned for completion in 1975. The byproducts plant at Amarillo will be capable of producing 60 million ounces of refined silver per year.

Kennecott Copper Corp. reported silver production of 4.2 million ounces of silver in 1973 from the processing of 66.5 million tons of copper ore. This compared with 4.3 million ounces of silver from 58.5 million tons of ore mined in 1972. The average price received for the year was $2.56 per ounce in 1973 compared with $1.68 per ounce in 1972.

Day Mines, Inc., of Wallace, Idaho, operates several mines in Idaho and Washington, and has interests in others. During 1973, silver production from all Day Mines sources amounted to 1.3 million ounces, about an 18% increase over that of 1972.

Smelter and refinery reports show that 34.6 million ounces of silver were generated from old scrap and 41.3 million ounces from new scrap in 1973. These were combined with output from foreign and domestic concentrates and ores for a total refinery production of 151.3 million ounces in 1973, about 8% more than in 1972.

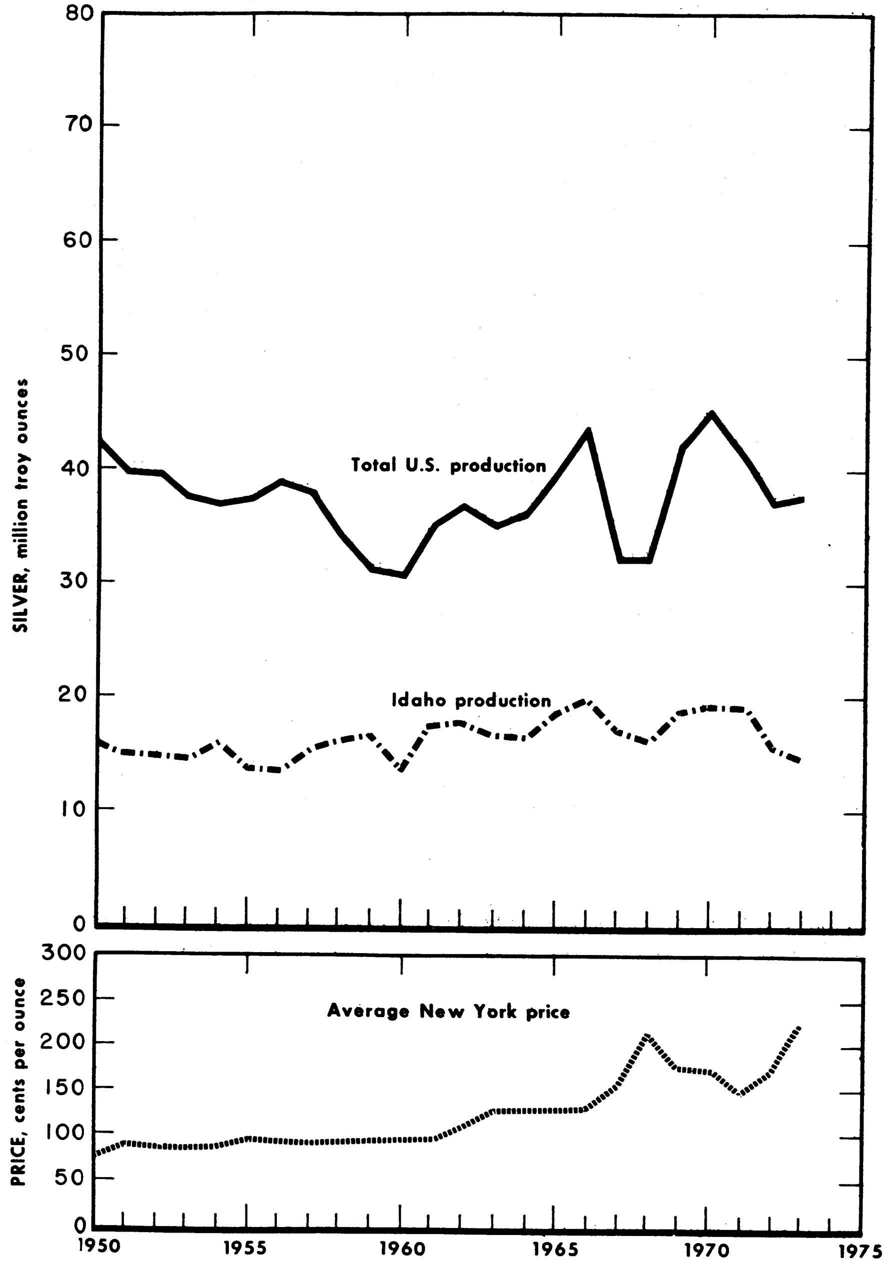

Figure 1.—Silver production in the United States and Idaho and price per ounce.

CONSUMPTION AND USES

Silver consumption in industry and the arts, as reported to the Bureau of Mines by manufacturers and consumers, increased 30% over the quantity consumed in 1972. There were significant percentage increases in use in catalysts (75%), miscellaneous (49%), sterling ware (48%), and brazing alloys and solders (45%). Substantial increases were used in photography (36%) and contacts and conductors (10%). Use in commemorative medals and other collector items was estimated at 21.9 million ounces in 1973 compared with 11.4 million ounces in 1972. Excluding coinage from the totals, the following four categories of use consumed more than 77% of the total silver: photography, 27%; contracts and conductors, 21%; sterling ware, 20%; and brazing alloys and solders, 9%. Consumption in jewelry showed a 19% increase. Sharply expanding uses were shown in dental and medical supplies and in mirrors. Silver used in domestic coinage declined to 0.9 million ounces in 1973 compared with 2.3 million ounces used in 1972.

Silver consumed in commemorative medals, embossed bars, and small ingots rose sharply during 1973, and amounted to 11% of total silver consumption. The 21.9 million ounces used contributed to the increases recorded in the sterling ware and miscellaneous categories shown in table 9.

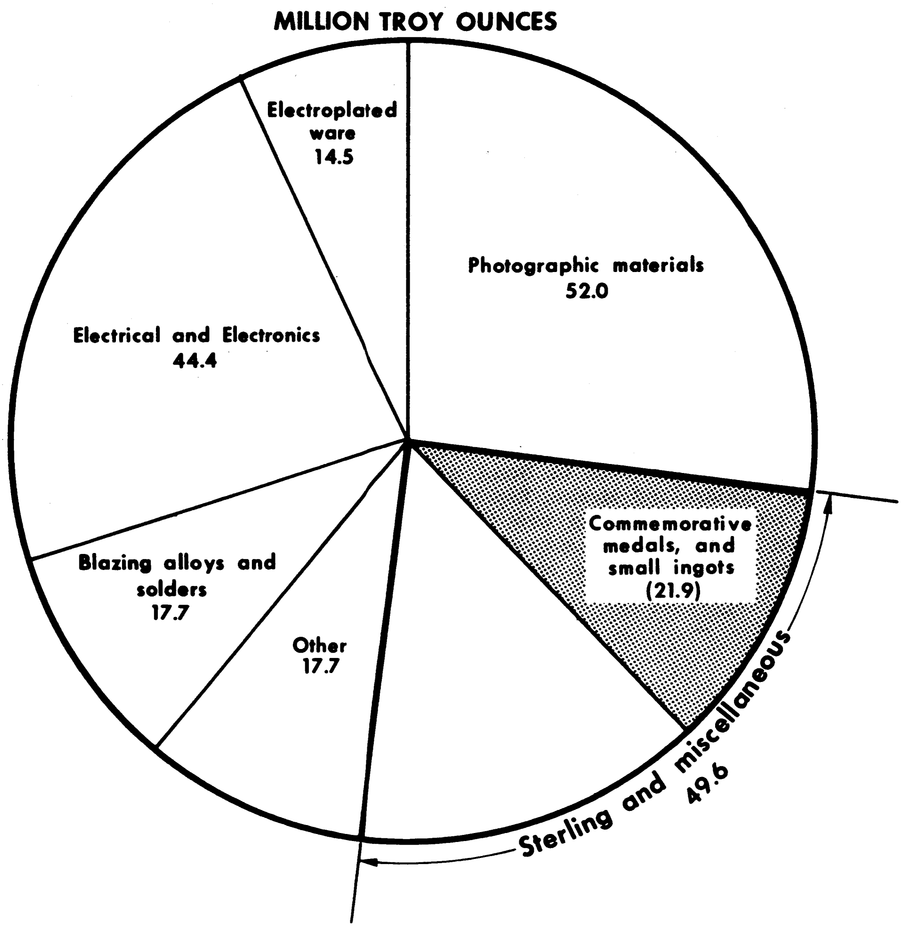

Figure 2.—Silver consumption in the United States, 1973.

STOCKS

The Treasury bullion stock outflow in 1973 totaled 0.7 million ounces, all of which was consumed in U.S. coinage for the continued production of the Eisenhower 40% silver dollar.

Total yearend visible stocks of silver were estimated at 181.3 million ounces, which consisted of industry stocks, 38.4 million ounces; Defense Department stocks, 6.1 million ounces; Treasury bullion, 45.1 million ounces; COMEX, 64.3 million ounces; and Chicago Board of Trade stocks, 27.4 million ounces. Total yearend stocks were 25.8 million ounces less, or 12%, than at the end of 1972.

PRICES

New York prices for silver in 1973, as quoted daily by Handy & Harman, ranged from a low of 196.50 cents per ounce on January 24, 1973, to a high of 328.00 cents per ounce on December 27, 1973. This upward trend extended the advance that began in 1971. Problems of supply and strong industrial demand contributed to the advance. Worldwide inflation and fluctuating international currency values increased the speculative demand for silver. The average price for silver during 1973 was 255.8 cents per ounce in New York.

Prices for spot delivery on the London Bullion Market ranged from a low of 195.5 cents per ounce (U.S. equivalent) on January 23, 1973, to a high of 325.6 cents per ounce on December 31, 1973, and averaged 254.1 cents for the year.

Prices also advanced sharply on the futures markets with increased trading activity. The trading volume on the COMEX increased to 12.4 billion ounces, up from 7.9 billion ounces traded in 1972. A monthly record trading of 1.35 billion ounces took place in December. Silver futures trading was also active on the Chicago Board of Trade, where 8.2 billion ounces were traded in 1973 compared with 3.8 billion ounces in 1972.

FOREIGN TRADE

Silver exports declined sharply in 1973 to 11.2 million ounces, less than half of the total exported in 1972. About 23% went to the Netherlands, 22% to Canada, 17% to West Germany, and 9% each to France and Belgium-Luxembourg. Significant quantities also went to Brazil, the United Kingdom, and Mexico. Exports of waste, scrap, and sweepings went mainly to West Germany, Belgium-Luxembourg, and the United Kingdom; most bullion went to the Netherlands, Canada, France, and West Germany.

Silver imports increased sharply in 1973 to 130.7 million ounces compared with 65.4 million ounces in 1972. About 62% of the imported silver was in refined bullion. The main sources of imports were Mexico (43%), Canada (28%), the United Kingdom (10%), and Peru (10%). Net imports were 119.5 million ounces in 1973 compared with 35.7 million ounces in 1972.

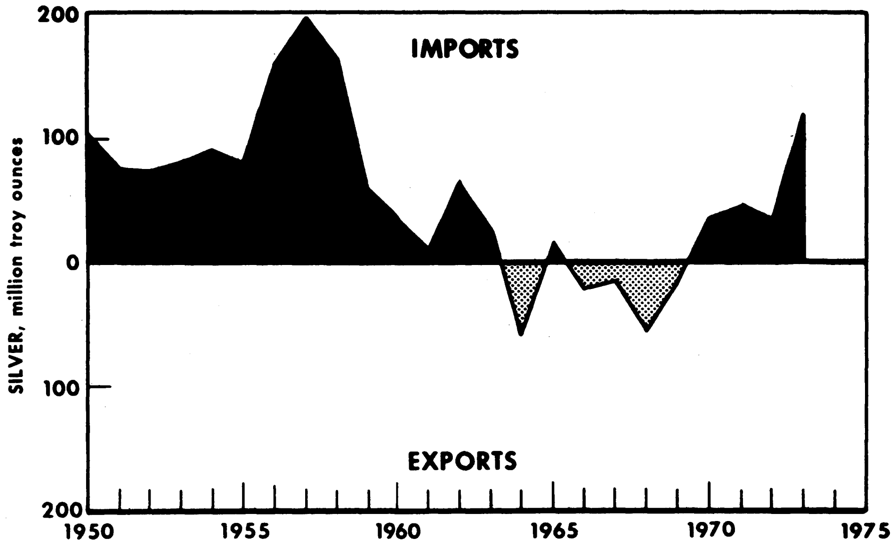

Figure 3.—Net exports or imports of silver, 1950–73.

WORLD REVIEW

World output of silver increased 11.7 million ounces to a total of 305.9 million ounces, an increase of 4% over that produced in 1972. The major increase in 1973 was the Canadian gain of 4.1 million ounces. Mexican and Peruvian silver output was also higher than in 1972, and U.S. production rose about 0.6 million ounces. Australian production increased about 0.4 million ounces in 1973. Western Hemisphere output of silver accounted for about 60% of the world production.

World consumption in arts and industry rose sharply to an estimated 463 million ounces, up about 72 million ounces over that consumed in 1972. The United States had the largest increase in consumption, from 151.1 million ounces in 1972 to 195.9 million ounces in 1973. Coinage requirements for the world declined from 36.5 million ounces in 1972 (revised) to 20.0 million ounces in 1973. Total non-Communist silver consumption exceeded production by 77.1 million ounces. This production and consumption gap was met by secondary recovery and reduction of stocks.

Australia.—Silver output of 23.2 million ounces was 2% more than that produced in 1972. The leading Australian silver producer was Mount Isa Mines, Ltd. (49% owned by ASARCO), which had a 1973 output of 8.8 million ounces, which was slightly below 1972 production. Mount Isa is also a major producer of lead, zinc, and copper.

Canada.—Canada's primary production of silver in 1973 was the highest on record. Reported output of 48.2 million ounces[2] was 3.4 million ounces greater than in 1972. Canada continued as the leading world producer of silver. The increase was mainly attributable to the greater output at several base-metal mines that produce silver as a byproduct, particularly at Mattabi Mines Ltd., which completed its first full year of operation at its zinc-lead-copper-silver property in the Sturgeon Lake area of Northwestern Ontario. Production from the silver-cobalt ores mined in the Cobalt-Gowganda area of northern Ontario was little changed from that of 1972.

Ore production by Texasgulf, Inc. wholly owned subsidiary, Ecstall Mining Ltd., at the Kidd Creek mine in Timmins, Ontario, continued at the rate of 3.6 million tons per year. Work began on plans to expand operations to 5.0 million tons annually. The greatest silver producer in Canada, the

[2] George, J. G. Silver. Can. Min. J., February 1974, p. 103.

Kidd Creek mine, produced about 22% of Canada's total 1973 output. Mine output of 10.7 million ounces in 1973 was about 16% below 1972 production. From the start of operations in 1966 and through 1973, the Kidd Creek mine produced a total of 24.9 million tons of ore averaging 1.53% copper, 0.39% lead, 3.73% zinc, and 4.26 ounces of silver per ton; remaining ore reserves above the 2,800-foot level were reported about 95.0 million tons.[3]

Cominco Ltd., the largest silver producer in British Columbia, derived its output from the lead-zinc-silver ore of its Sullivan mine at Kimberly and from purchased ores and concentrates. Cominco was also one of Canada's leading producers of refined silver and, in 1973 produced 9.6 million ounces at its refinery in Trail, compared with 7.0 million ounces in 1972.

Another mine, in an earlier period (1953–67) was the largest silver producer in Canada. It is owned by United Keno Hill Mines, Ltd. and located in the Yukon Territory. United Keno Hill produced 3.1 million ounces of silver compared with 2.5 million ounces in 1972, with 72% of the production coming from the Husky and No Cash properties. During the year, the Calumet mine, previously a good producer of silver, was closed and the site vacated.

Silver production in the Northwest Territories was significantly higher than in 1972 because of greater output by Echo Bay Mines Ltd. and Terra Mining and Exploration Ltd. Echo Bay, a subsidiary of International Utilities Corp., began operations in 1964. Since then, and operating a 140-ton-per-day mill, it has produced a total of 16 million ounces of silver and a minor amount of copper. It was reported that some of the treated ore had yield values of up to 70 ounces of silver per ton.

Exploration work continued in 1973 by Dynasty Exploration Ltd., and its associate, Atlas Exploration Ltd., on the Plata silver-lead property in the Hess Mountains of the Yukon Territory. In several exposed veins, it was reported that the ore assayed a high percentage of silver and lead.

Dominican Republic.—Rosario Resources Corp. announced it was increasing the production capacity of the gold-silver processing plant, under construction at its Pueblo Viejo mine in the Dominican Republic, from 6,000 to 8,000 tons per day. During 1973, additional exploration increased the estimated oxide ore reserves from 20 million to 30 million tons. Annual production at Pueblo Viejo, an open pit mine, was projected to be about 1.5 million ounces of silver and 350,000 ounces of gold. Plant completion was scheduled for the latter part of 1974. The operation is owned by Rosario Resources (40%), J. R. Simplot and Co. (40%), with a 20% equity participation by the Central Bank of the Dominican Republic.

Honduras.—Silver production from the El Mochito mine of Rosario Resources Corp. (formerly New York and Honduras Rosario Mining Co.) was 3.2 million ounces, about the same as in 1972. The mine produced 311,682 tons of ore and the mill processed 311,576 tons of ore averaging 11.9 ounces of silver per ton, with additional amounts of gold, lead, and zinc. Ore reserves in the main area amounted to 1.8 million tons.

Japan.—Mine production of silver in Japan was 8.5 million ounces, a decrease of 15% from 1972 production. Japanese silver consumption rose from 54.4 million ounces in 1972 to 67.5 million ounces in 1973. No silver was used in coinage. With Mexico, Peru, and Australia as its major suppliers in 1973, Japan imported 32.0 million ounces of silver and exported 100,000 ounces. Japanese Government stocks of silver were reported at 16.0 million ounces, unchanged from 1972.[4]

Mexico.—Silver production in Mexico rose to 38.8 million ounces, 3% higher than in 1972. During the year it was announced that silver output would be increased 10 million ounces in the next 2 years by development of deposits previously disregarded because of low world prices.

Tormex Mining Developers, in which Ducanex Resources and Pure Silver Mines Ltd. (Canadian firms) hold just over 26% interest each, reported that construction was completed on a 500-ton-per-day concentrator at the Encantada mine. The mine is owned by Tormex (40%), and its Mexican partner, Industrias Peñoles, S.A. (60%). It was expected that operators would ship 6,000 tons of concentrate, grading about 40% lead, and 30 ounces per ton of silver, to the smelter each month. This silver-lead property is located in the northern part of the country, 200 miles southeast of Chihuahua.

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[3] Texasgulf, Inc., 1973 Annual Report. P. 6.

[4] Handy & Harman. The Silver Market, 1973. 58th Annual Review. 1973, 16 pp.

The surface and underground development work at the Guanajuato, Mexico, silver-gold properties of Pure Silver Mines Ltd. (Canada) and its Mexican partners, Cia. Mineral Fresnillo S.A. and Industrias Peñoles S.A., continued in 1973. An independent feasibility report on the proposed integrated mining and milling operation was expected to be completed by the end of October 1973. The proposed operation, at a rate of 2,000 tons per day, is based on indicated silver-gold ore reserves of approximately 4.4 million short tons at the Mother Lode, Peregrina, and Cebada mines. At the Las Torres mine, the main production shaft was completed to the 2,130-foot level, with most lateral work continuing on the 1,600-foot level. Good values in silver and gold have been reported. At the Peregrina mine, a new 12-foot by 14-foot shaft was scheduled for completion to 1,270 feet at the end of August 1973. Deepening of the Cebada shaft to 1,270 feet was completed.

The American Smelting and Refining Co. subsidiary, ASARCO Mexicana, S.A. (49% owned by ASARCO) produced 14.8 million ounces of silver during 1973, a decrease of 5% from 1972 production. Operations at company mines were normal. Ore reserves were maintained except at Parral, where mining operations were being phased out, with plans to terminate in 1974 owing to exhaustion of ore reserves.

In December 1973 ASARCO reached agreement in principle with the main Mexican stockholders of ASARCO Mexicana to sell an additional 15% of the stock of ASARCO Mexicana to Mexican investors, thus reducing its holdings to 34% of the outstanding stock.[5]

Peru.—Peru was the world's second largest producer of silver in 1973. Output increased to 42.0 million ounces, compared with 40.2 million ounces in 1972. Silver production was primarily a byproduct of base-metal mining.

The largest silver producer and refining company in Peru was the Cerro Corp. Its totally owned subsidiary, Cerro de Pasco Corp., operated six metal mines. The total silver refined in 1973 at Cerro's reduction works at La Oroya from its own and purchased ores was 19.9 million ounces, 47% of the total silver output of Peru. This compared with 23.0 million ounces produced in 1972.

On January 1, 1974, the Peruvian Government expropriated Cerro Corp. holdings in Cerro de Pasco. It was reported that the Peruvian Government would provide compensation for the company's mining, smelting, and refining properties.

TECHNOLOGY

In 1973 the Bureau of Mines reported on its investigation of treating ores in which silver occurs as a sulfide, in jarosite, in iron oxide, and in manganese carbonate-oxide associations.[6] Silver ores from the Candelaria District, Nevada, and Round Mountain District, Colorado, were the subjects of study. Leaching these ores with a sulfurous acid-sodium chloride system increased silver extraction up to 61% over that obtained by conventional cyanidation techniques. The Bureau published a report that described two processes for recovering silver and other metals from the magnetic fraction of waste generated by the primary smelting of zinc in horizontal retort distillation furnaces.[7]

The Calico silver-barite deposits near Barstow, Calif. are a potentially important silver and barite resource. Exploraiton performed in the past by two major mining companies has outlined large tonnages of ore containing 2 to 3 ounces of silver per ton and 7% to 15% barite. Laboratory beneficiation work was done by the Bureau of Mines on four samples to develop methods for recovering the silver and/or barite. Cyanidation recovered from 47% to 60% of the silver, and from 75% to 90% of the barite was recovered from either the natural ore or from cyanidation residues. Salt roasting followed by cyanidation recovered a higher percentage of the silver but precluded recovery of the barite concentrate from the leach tails.[8]

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[5] American Smelting and Refining Company. 1973 Annual Report. P. 19.

[6] Scheiner, B. J., D. L. Pool, J. J. Sjoberg, and R. E. Lindstrom. Extraction of Silver From Refractory Ores. BuMines RI 7736, 1973, 11 pp.

[7] Powell, H. E. and L. W. Higley. Recovery of Zinc, Copper, Silver, and Iron From Zinc Smelter Residue. BuMines RI 7754, 1973, 15 pp.

[8] Agey, W. W., J. V. Batty, H. W. Wilson, and W. J. Wilson. Beneficiation of Calico District, California, Silver-Barite Ores. BuMines RI 7730, 1973, 15 pp.

At the Bureau of Mines Intermountain Field Operation center, a study was conducted that gave an economic analysis of copper system byproducts and discussed the identification and classification of byproduct metals, and their supply. The report gave the sources of supply of individual byproduct metals to indicate importance to total supply. The study also included information on the reserves-resource base supporting byproduct output, reserve estimates, and the demand aspects of silver.[9]

The Bureau of Mines continued research on a project entitled, "Extraction of Silver and Other Metals From Refractory Ores, and Mine Wastes." The objective was to develop new or improved extraction processes to recover silver and associated metals from refractory and marginal ores and deposits too small to support amortization of a conventional cyanide plant. Procedures to develop a low-cost pit cyanidation, carbon-in-pulp technique for recovering silver from old mill tailings appeared promising.

Two companies in Japan jointly developed a commercial process for manufacturing the fine silver powder consisting of submicrometer-size particles. The technology involved placing a given metal in a vacuum oven and heating the metal above its melting point in an inert gas atmosphere. The resulting vapor was condensed to obtain metal powder between 0.01 and 0.02 micrometer in diameter. The process was applicable to silver, copper, aluminum, and various other metals and alloys. Fine metal powders are used in electronics (silver pastes), powder metallurgy, and catalysts.[10]

[9] Petrick, A., H. J. Bennett, E. Starch, and R. C. Weisner. The Economics of Byproduct Metals (In Two Parts), Part I, Copper System. BuMines IC 8569, 1973, pp. 39–48.

[10] American Metal Market. Nippon Soda, Ulvac Develop Process For Mass Producing Fine Metal Powder. V. 80, No. 136, Aug. 10, 1973, p. 8.

Table 2.—Mine production of recoverable silver in the United States, by month

(Thousand troy ounces)

Month	1972	1973
January	3,405	3,232
February	3,841	3,215
March	3,934	3,138
April	3,755	2,838
May	3,022	3,331
June	2,948	2,955
July	2,517	3,063
August	2,868	3,296
September	2,746	3,192
October	2,902	3,197
November	2,613	3,097
December	2,682	3,273
Total	37,233	37,827

Table 3.—Twenty-five leading silver-producing mines in the United States in 1973, in order of output

Rank	Mine	County and State	Operator	Source of silver
1	Galena	Shoshone, Idaho	American Smelting and Refining Co.	Silver ore.
2	Berkeley Pit	Silver Bow, Mont	The Anaconda Company	Copper ore.
3	Sunshine	Shoshone, Idaho	Sunshine Mining Co	Silver ore.
4	Lucky Friday	do	Hecla Mining Co	Lead ore.
5	Utah Copper	Salt Lake, Utah	Kennecott Copper Corp	Copper, gold ores.
6	Bulldog Mountain	Mineral, Colo	Homestake Mining Co	Silver ore.
7	Bunker Hill	Shoshone, Idaho	The Bunker Hill Co	Lead-zinc ore.
8	Buick	Iron, Mo	Amax Lead Co. of Missouri	Lead ore.
9	Pima	Pima, Ariz	Pima Mining Co	Copper ore.
10	Twin Buttes	do	Anamax Mining Co	Do.
11	White Pine	Ontonagon, Mich	White Pine Copper Co	Do.
12	Burgin	Utah, Utah	Kennecott Copper Co	Lead-zinc ore.
13	Sierrita	Pima, Ariz	Duval Sierrita Corp	Copper ore.
14	Star Unit	Shoshone, Idaho	The Bunker Hill Co. and Hecla Mining Co.	Lead-zinc ore.
15	Butte Hill Copper Mines.	Silver Bow, Mont	The Anaconda Company	Copper ore.
16	Tyrone	Grant, N. Mex	Phelps Dodge Corp	Do.
17	Copper-Queen-Lavender Pit.	Cochise, Ariz	do	Do.
18	San Manuel	Pinal, Ariz	Magma Copper Co	Do.
19	Morenci	Greenlee, Ariz	Phelps Dodge Corp	Do.
20	Mission Unit	Pima, Ariz	American Smelting and Refining Co.	Do.
21	Crescent	Shoshone, Idaho	The Bunker Hill Co	Silver ore.
22	Leadville	Lake, Colo	American Smelting and Refining Co.	Lead-zinc ore.
23	Idarado	Ouray and San Miguel, Colo.	Idarado Mining Co	Copper-lead-zinc ore.
24	Mineral Park	Mohave, Ariz	Duval Corp	Copper ore.
25	Magma	Pinal, Ariz	Magma Copper Co	Do.

Table 4.—Production of silver in the United States in 1973, by State, type of mine, and class of ore, yielding silver, in terms of recoverable metal

State	Placer (troy ounces of silver)	Lode					
		Gold ore		Gold-silver ore		Silver ore	
		Short tons	Troy ounces of silver	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver
Alaska	300	--	--	--	--	--	--
Arizona	--	W	W	[1] 112,763	[1] 34,184	W	W
California	237	[2] 3,412	[2] 13,125	W	W	--	--
Colorado	177	[2] 13,677	[2] 21,661	W	W	W	W
Idaho	--	--	--	226	743	436,328	7,936,810
Michigan	--	--	--	--	--	--	--
Missouri	--	--	--	--	--	--	--
Montana	--	948	830	16,974	75,730	23,246	182,012
Nevada	--	W	W	W	W	2,711	42,014
New Mexico	--	W	W	--	--	W	W
New York	--	--	--	--	--	--	--
Oregon	--	195	127	648	1,155	--	--
South Dakota	--	1,573,763	71,939	--	--	--	--
Tennessee	--	--	--	--	--	--	--
Utah	--	W	W	W	W	--	--
Other States [3]	--	61,541	154,045	--	--	39	24
Total	714	1,653,536	261,727	130,611	111,812	462,324	8,160,860
Percent of total silver	([4])	--	1	--	([4])	--	22

State	Lode—Continued					
	Copper ore		Lead ore		Zinc ore	
	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver
Alaska	--	--	12	528	--	--
Arizona	163,879,867	7,130,066	--	--	--	--
California	--	--	W	W	--	--
Colorado	W	W	W	W	W	W
Idaho	W	W	W	W	W	W
Michigan	8,884,136	850,273	--	--	--	--
Missouri	--	--	7,585,624	2,057,732	--	--
Montana	18,976,738	4,025,210	195	638	--	--
Nevada	[5] 11,653,738	[5] 581,141	--	--	--	--
New Mexico	[1] 26,416,493	[1] 979,961	--	--	W	W
New York	--	--	--	--	963,403	54,345
Oregon	--	--	--	--	--	--
South Dakota	--	--	--	--	--	--
Tennessee	--	--	--	--	--	--
Utah	W	W	--	--	--	--
Other States [3]	150,564	20,561	500	266	297,020	13,325
Total	229,961,536	13,587,212	7,586,331	2,059,164	1,260,423	67,670
Percent of total silver	--	36	--	5	--	([4])

See footnotes at end of table.

Table 4.—Production of silver in the United States in 1973, by State, type of mine, and class of ore, yielding silver, in terms of recoverable metal—Continued

State	Lode—Continued					
	Copper-lead, lead-zinc, copper-zinc, and copper-lead-zinc ores		Old tailings, etc.		Total	
	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver [6]	Short tons	Troy ounces of silver
Alaska	--	--	--	--	12	828
Arizona	93,284	34,922	670	79	164,086,584	7,199,251
California	[7] 3,422	[7] 12,377	3	30,158	6,837	55,897
Colorado	[8] 1,206,714	[8] 3,908,651	7,068	11,293	1,227,459	3,941,782
Idaho	[9] 1,221,650	[9] 5,682,271	--	--	1,658,204	13,619,824
Michigan	--	--	--	--	8,884,136	850,273
Missouri	--	--	--	--	7,585,624	2,057,732
Montana	328	4,122	66,693	61,327	19,085,122	4,349,869
Nevada	--	--	32	505	11,656,481	623,660
New Mexico	[10] 129,909	[10] 131,308	--	--	26,546,402	1,111,269
New York	--	--	--	--	963,403	54,345
Oregon	--	--	--	--	843	1,282
South Dakota	--	--	--	--	1,573,763	71,939
Tennessee	1,322,930	73,104	--	--	1,322,930	73,104
Utah	[5 11] 38,597,788	[5 11] 3,615,728	--	3,310	38,597,788	3,619,038
Other States [3]	212,289	6,662	--	2,167	721,953	197,050
Total	42,788,314	13,469,145	74,466	108,839	283,917,541	37,827,143
Percent of total silver	--	36	--	(4)	--	100

W Withheld to avoid disclosing individual company confidential data; included with other ore classes.
[1] Includes gold ore and silver ore.
[2] Includes gold-silver ore.
[3] Includes Illinois, Maine, Oklahoma, and Washington.
[4] Less than ½ unit.
[5] Includes gold ore, and gold-silver ores.
[6] Includes byproduct silver recovered from tungsten ore in California, fluorspar ore in Colorado and Illinois, and uranium ore in Utah.
[7] Includes lead ore.
[8] Includes silver ore, copper ore, lead ore, and zinc ore.
[9] Includes copper ore, lead ore, and zinc ore.
[10] Includes zinc ore.
[11] Includes copper ore.

Table 5.—Mine production of recoverable silver in the United States, by State

(Troy ounces)

State	1969	1970	1971	1972	1973
Alaska	2,030	2,189	868	288	828
Arizona	6,141,022	7,330,417	6,169,623	6,652,800	7,199,251
California	491,927	451,150	443,761	175,467	55,897
Colorado	2,598,563	2,933,363	3,389,748	3,663,832	3,941,782
Idaho	18,929,697	19,114,829	19,139,575	14,250,725	13,619,824
Maine	(1)	63,227	41,193	16,251	(1)
Michigan	1,009,022	891,579	670,052	785,100	850,273
Missouri	1,442,090	1,816,978	1,660,879	1,971,530	2,057,732
Montana	3,429,314	4,304,326	2,747,557	3,325,052	4,349,869
Nevada	884,155	718,011	601,470	595,351	623,660
New Mexico	465,591	781,952	782,441	1,016,880	1,111,269
New York	31,755	23,830	17,928	25,070	54,345
Oklahoma	[1] 319,718	[1] 325,887	[1] 362,646	[1] 269,262	[1] 197,050
Oregon	4,749	3,594	3,790	2,252	1,282
Pennsylvania	(1)	(1)	(1)	--	--
South Dakota	124,497	119,766	106,785	99,992	71,939
Tennessee	78,614	94,770	131,349	83,466	73,104
Utah	5,953,567	6,029,737	5,294,477	4,299,604	3,619,038
Total	41,906,311	45,005,605	41,564,142	37,232,922	37,827,143

[1] Production of Maine (1969 and 1973), Oklahoma, Pennsylvania (1969–71), Washington (1969–73), Wyoming (1969), North Carolina (1971), and Illinois (1971–73), combined to avoid disclosing individual company confidential data.

Table 6.—Silver produced in the United States from ore, old tailings, etc., in 1973, by State and method of recovery, in terms of recoverable metal

State	Total ore, old tailings, etc., treated[1,2] (thousand short tons)	Ore and old tailings to mills					Crude ore, old tailings, etc., to smelters[1]	
		Thousand short tons[1,2]	Recoverable in bullion		Concentrates smelted and recoverable metal			
			Amalgamation (troy ounces)	Cyanidation (troy ounces)	Concentrates (short tons)	Troy ounces	Thousand short tons	Troy ounces
Alaska	(3)	--	--	--	--	--	(3)	528
Arizona	181,426	181,033	--	--	3,405,828	7,067,199	393	132,052
California	7	5	--	--	1,572	53,018	2	2,642
Colorado	1,297	1,290	347,109	--	171,430	3,566,855	7	27,641
Idaho	1,658	1,656	--	--	184,858	13,610,898	2	8,926
Michigan	8,884	8,884	--	--	246,162	850,273	--	--
Missouri	7,586	7,586	--	--	861,166	2,057,732	(3)	--
Montana	19,085	18,976	--	--	405,219	4,029,135	109	320,734
Nevada	[4,5] 24,584	[4,5] 24,502	--	152,895	372,163	463,634	82	7,131
New Mexico	26,546	26,489	--	--	882,538	1,105,869	57	5,400
New York	1,094	1,094	--	--	158,042	54,345	--	--
Oregon	1	--	--	--	--	--	1	1,282
South Dakota	1,574	1,574	--	71,939	--	--	--	--
Tennessee	3,458	3,458	--	--	170,535	73,104	--	--
Utah	39,153	38,993	--	--	868,754	3,288,391	160	330,647
Other States[6]	[5] 721	[5] 721	--	36,012	74,797	160,913	(3)	125
Total	317,074	316,261	347,109	260,846	7,803,064	36,381,366	813	837,108

1 Includes some nonsilver-bearing ore not separable.
2 Excludes tonnages of fluorspar, tungsten, and uranium ores from which silver was recovered as a byproduct.
3 Less than ½ unit.
4 Includes tonnages from which silver is heap leached.
5 Includes tonnages from which silver is vat leached.
6 Includes Illinois, Maine, Oklahoma, and Washington.

Table 7.—Silver produced at amalgamation and cyanidation mills in the United States and percentage of silver recoverable from all sources

Year	Bullion and precipitates recoverable (troy ounces)		Silver recoverable from all sources (percent)			
	Amalgamation	Cyanidation	Amalgamation	Cyanidation	Smelting[1]	Placers
1969	83,775	49,312	0.20	0.11	99.68	0.01
1970	95,287	24,892	.21	.05	99.73	.01
1971	993	106,785	(2)	.26	99.74	(2)
1972	2,490	99,992	.01	.27	99.72	(2)
1973	347,109	260,846	.92	.69	98.39	(2)

1 Crude ores and concentrates.
2 Less than ½ unit.

Table 8.—Silver produced at refineries in the United States, by source

(Thousand troy ounces)

Source	1972	1973
Concentrates and ores:		
Domestic	38,366	36,494
Foreign	39,151	38,877
Total	77,517	75,371
Old scrap	31,090	34,556
New scrap	31,815	41,348
Total production	[1] 140,423	151,275

[1] Data does not add to total shown because of independent rounding.

Table 9.—U.S. consumption of silver, by end use

(Thousand troy ounces)

Final Use	1972	1973
Electroplated ware	12,716	14,542
Sterling ware [1]	27,163	40,100
Jewelry	4,870	5,778
Photographic materials	38,251	51,979
Dental and medical supplies	1,991	3,022
Mirrors	1,225	2,579
Brazing alloys and solders	12,214	17,736
Electrical and electronic products:		
Batteries	6,044	4,155
Contacts and conductors	36,434	40,209
Bearings	344	375
Catalysts	3,430	5,988
Miscellaneous [1 2]	6,381	9,478
Total net industrial consumption	151,063	195,941
Coinage	2,284	920
Total consumption	153,347	196,861

[1] Silver used in commemorative medals estimated at 11.4 million ounces in 1972 and 21.9 million ounces in 1973, distributed partly in sterling ware and partly in miscellaneous.
[2] Includes silver-bearing copper, silver-bearing lead anodes, ceramics, paints, etc.

Table 10.—Value of silver exported from and imported into the United States

(Thousand dollars)

Year	Exports	Imports
1971	19,798	82,225
1972	49,260	101,580
1973	27,638	330,456

Table 11.—U.S. exports of silver in 1973, by country

(Thousand troy ounces and thousand dollars)

Country	Ore and concentrates		Waste and sweepings		Refined bullion	
	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	--	--	1	3	--	--
Australia	--	--	--	--	2	3
Belgium-Luxembourg	5	9	1,026	2,383	1	2
Brazil	--	--	126	355	783	1,945
Canada	21	32	48	79	2,386	6,105
Colombia	--	--	--	--	23	67
France	--	--	--	--	1,063	2,126
Germany, West	53	139	1,087	2,848	806	1,772
Italy	--	--	149	347	--	--
Japan	--	--	6	14	201	545
Mexico	--	--	--	--	289	647
Netherlands	--	--	--	--	2,590	6,975
Spain	--	--	32	70	64	129
Sweden	11	22	32	70	--	--
Switzerland	--	--	5	10	--	--
United Kingdom	47	91	358	850	--	--
Total	137	293	2,870	7,029	8,208	20,316

Table 12.—U.S. general imports of silver in 1973, by country

(Thousand troy ounces and thousand dollars)

Country	Ore and concentrates		Waste and sweepings		Dore and precipitates		Refined bullion	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	--	--	--	--	--	--	290	569
Australia	2,805	6,610	--	--	--	--	--	--
Belgium-Luxembourg	--	--	--	--	--	--	1,737	4,864
Canada	14,651	33,045	422	933	5,670	13,885	15,321	38,269
Chile	620	1,599	--	--	--	--	64	132
Colombia	28	69	--	--	--	--	--	--
France	--	--	--	--	11	24	--	--
Germany, West	--	--	(1)	(1)	--	--	--	--
Greece	--	--	4	1	--	--	--	--
Guatemala	--	--	--	--	--	--	1,000	2,941
Honduras	2,860	4,365	--	--	292	718	--	--
Jamaica	--	--	2	4	--	--	--	--
Japan	212	507	--	--	--	--	32	61
Korea, Republic of	--	--	--	--	--	--	16	29
Mexico	1,652	3,401	3,800	10,707	5,222	13,450	45,253	122,207
Netherlands	--	--	--	--	--	--	560	1,568
Nicaragua	66	124	--	--	9	20	--	--
Norway	43	57	--	--	--	--	--	--
Panama	--	--	8	17	--	--	--	--
Peru	9,615	22,575	--	--	--	--	3,846	8,967
Philippines	423	1,003	30	65	--	--	24	54
Romania	--	--	--	--	(1)	1	--	--
South Africa, Republic of	1,015	1,572	--	--	--	--	--	--
Switzerland	--	--	--	--	--	--	1	4
United Kingdom	(1)	(1)	--	--	2	7	13,075	36,032
Total	33,990	74,927	4,266	11,727	11,206	28,105	81,219	215,697

[1] Less than ½ unit.

Table 13.—Silver: World production by country[1]

(Thousand troy ounces)

Country[2]	1971	1972	1973 p
North and Central America:			
Canada	46,024	44,792	48,156
Costa Rica	--	--	(3)
El Salvador	215	177	123
Guatemala	--	6	e 7
Haiti e	17	17	17
Honduras	3,642	3,595	3,152
Mexico	36,657	37,483	38,788
Nicaragua	261	357	180
United States	41,564	37,233	37,827
South America:			
Argentina	r 3,179	2,122	e 2,500
Bolivia[4]	5,369	5,581	5,708
Brazil	624	318	327
Chile	2,729	4,689	5,035
Colombia	68	70	75
Ecuador	e 70	69	76
Peru	38,398	40,188	42,021
Europe:			
Austria[5]	220	192	193
Czechoslovakia e	1,100	1,100	1,100
Finland	623	625	793
France	r 5,307	3,294	4,180
Germany, East e	5,000	5,000	7,000
Germany, West	1,800	1,736	1,382
Greece[5]	462	--	e 100
Hungary e	6	6	7
Ireland	1,432	1,553	1,839
Italy	1,236	2,170	1,349
Poland e	200	210	220
Portugal	264	230	108
Romania e	1,000	1,000	1,100
Spain[5]	e 1,640	e 1,640	2,249
Sweden	3,895	4,255	e 4,500
U.S.S.R. e	39,000	40,000	41,000
Yugoslavia	3,354	3,582	4,302
Africa:			
Algeria e	200	r 220	157
Kenya	--	--	(3)
Morocco	r 2,942	3,376	3,518
Rhodesia, Southern[6]	91	126	169
South Africa, Republic of	3,378	3,294	3,652
South-West Africa, Territory of[7,8]	r 1,728	1,357	1,563
Tanzania	r (3)	(3)	(3)
Tunisia	106	242	e 250
Zaire	1,470	2,078	1,995
Zambia[8]	194	109	2
Asia:			
Burma	685	587	754
China, People's Republic of e	800	800	800
India	121	142	138
Indonesia	285	279	301
Japan	11,293	10,021	8,552
Korea, North e	700	700	700
Korea, Republic of	1,543	1,770	1,490
Philippines	1,940	1,848	1,892
Taiwan	73	74	93
Oceania:			
Australia	21,703	22,796	23,201
Fiji	r 20	24	30
New Zealand	66	31	49
Papua New Guinea	19	995	1,196
Total	r 294,713	294,159	305,916

e Estimate. p Preliminary. r Revised.
[1] Recoverable content of ores and concentrates produced unless otherwise noted.
[2] In addition to the countries listed Bulgaria, Thailand, Turkey, and several African countries produce silver, but information is inadequate to make reliable output estimates.
[3] Less than ½ unit.
[4] Includes production by the State mining company COMIBOL plus the exports of medium and small (private sector) mines.
[5] Smelter and/or refinery production.
[6] Output of Inyati mine only.
[7] Data represents recoverable content of Tsumeb Corp. Ltd. concentrates for year ending June 30, 1971, and calendar year production in 1972 and 1973. Silver production from July 1 to December 31, 1971, was 649,343 troy ounces.
[8] Includes recovery from copper refinery sludges.

Slag—Iron and Steel

By Harold J. Drake[1]

Production of processed iron and steel slag, in the aggregate, increased in 1973. Output of iron blast-furnace slag rose 15% in quantity and 18% in value, but output of steel slag decreased 4% in quantity and 2% in value. Nearly all of the increased production of iron slag was accounted for by air-cooled blast-furnace slag. As in past years, a considerable portion of steel slag was recycled to blast furnaces, whereas little, if any, iron slag was so utilized.

Prices of iron and steel slags, continuing the trend of recent years, were stable. The average price for all iron slag was up 2% and that of steel slag was up 3%. Imports of slag declined 13% in quantity and 18% in value. Exports increased 35% in quantity and more than doubled in value, indicating increased shipments of high-value material.

Table 1.—Iron-blast-furnace slag processed in the United States, by type

(Thousand short tons and thousand dollars)

Year	Air-cooled				Granulated		Expanded		Total	
	Screened		Unscreened							
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1972	20,968	43,652	910	1,135	1,657	3,059	1,518	5,529	25,053	53,375
1973	23,692	50,737	1,279	1,512	1,999	3,667	1,852	6,936	28,822	62,852

Source: National Slag Association.

DOMESTIC PRODUCTION

Increased production of iron and steel in 1973 resulted in higher output of iron slag. Production of iron-blast-furnace slag totaled 28.8 million tons valued at $62.9 million. Output of steel slag totaled 9.7 million tons valued at $10.8 million.

Production of air-cooled blast-furnace slag totaled 25 million tons valued at $52.2 million, increases of 14% and 17%, respectively, over the levels of the preceding year. Approximately 95% of this material was crushed and screened to specifications; the remainder was crushed and used without screening. Granulated blast-furnace slag production reached 2 million tons valued at $3.7 million, increases of 21% and 20%, respectively. Production of expanded slag, at 1.9 million tons valued at $6.9 million in 1973, was up 22% in quantity and 25% in value.

The great bulk of the slag was produced in Ohio, Pennsylvania, Illinois, Indiana, and Michigan. A total of 1,713 plant and yard personnel worked 3,797,000 man-hours during 1973 in 90 air-cooled, 16 expanded, and 12 granulated slag plants. A total of 3,465,000 tons of slag-encrusted magnetic iron was recovered at these operations.

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Table 2.—Iron-blast-furnace slag processed in the United States, by State
(Thousand short tons and thousand dollars)

Year and State	Screened air-cooled		All types	
	Quantity	Value	Quantity	Value
1972				
Ohio	4,235	9,442	5,272	11,794
Pennsylvania	4,967	11,659	5,991	13,497
Illinois, Indiana, Michigan	4,519	8,760	5,351	11,525
Other States [1]	7,247	r 13,701	8,439	16,559
Total	20,968	r 43,562	25,053	53,375
1973				
Ohio	5,427	12,316	6,904	14,817
Pennsylvania	5,061	12,032	6,698	16,129
Illinois, Indiana, Michigan	5,945	12,181	6,799	15,174
Other States [1]	7,259	14,208	8,421	16,732
Total	23,692	50,737	28,822	62,852

r Revised.
[1] Includes, Alabama, California, Colorado, Kentucky, Louisiana, Maryland, Minnesota, New York, Texas, Utah, and West Virginia.

Source: National Slag Association.

CONSUMPTION AND USES

Because stocks of process slag are relatively small and constant from year to year, consumption virtually equals production, excluding the quantities that are recycled to blast-furnaces. The principal market has always been the construction industry which, in 1973, accounted for about 95% of the quantities consumed. Agricultural uses, sewage filtering medium, and mineral wool manufacture utilized the small remainder.

Increased consumption of screened iron-blast-furnace slag was reported in portland cement concrete construction, bituminous construction, and highway and airport construction. In total, these uses accounted for about 73% of the volume of screened air-cooled slag consumed in 1973. Declines in consumption were reported for railroad ballast, roofing granules, and sewage filtering medium. Consumption of unscreened air-cooled slag in highway and airport construction, the principal use, declined slightly. Consumption of granulated and expanded blast-furnace slags was up 21% from 1972. More granulated slag was used in highways and agriculture and less in cement and concrete blocks. Use of expanded slag in concrete blocks increased 23% but decreased 14% in cement manufacture.

Consumption gains were recorded for steel slag in miscellaneous base and fill applications, railroad ballast, bituminous mixes and agriculture, but declines were recorded in highway construction and paved areas.

Use technology was reviewed in a number of important papers in recent years.[2]

[2] National Slag Association. The Case for Superior Base Construction With Slag. NSA Bull. 171–1, 1971, 4 pp.
———. Use of Slag in Hollow Core Slabs. NSA Bull. 171–6, 1971, 2 pp.
———. Fire Resistance and Heat Transmission Properties of Concrete Masonry Made With Blast Furnace Slag Aggregate. NSA Bull. 172–1, 1972, 11 pp.
———. Pumping Slag Concrete. NSA Bull. 172–4, 1972, 2 pp.
———. Slag Roofs. NSA Bull. 172–6, 1972, 4 pp.
———. Laboratory Study of Base Course Materials Stabilized With Granulated Slag. NSA Bull. 172–7, 1972, 6 pp.
———. Slag Used to Stop Erosion. NSA Bull. 172–9, 1972, 2 pp.
———. Use of Pelletized Expanded Slag in Structural Concrete. NSA Bull. 172–14, 1972, 2 pp.
———. Slag for Use in Bituminous Concrete. NSA Bull. 173–1, 1973, 8 pp.
———. Air Cooled Blast Furnace Slag Bases. NSA Bull. 173–2, 1973, 8 pp.
———. Steel Furnace Slag—An Ideal Railroad Ballast. NSA Bull. 173–3, 1973, 2 pp.
———. Blast Furnace Slag—A Superior Railroad Ballast. NSA Bull. 173–4, 1973, 5 pp.

Table 3.—Shipments of iron-blast-furnace slag in the United States, by method of transportation

Method of transportation	1972 Quantity (short tons)	1972 Percent of total	1973 Quantity (short tons)	1973 Percent of total
Rail	4,341	17	5,366	19
Truck	19,952	80	22,640	78
Waterway	760	3	846	3
Total	25,053	100	28,852	100

Source: National Slag Association.

Table 4.—Air-cooled iron-blast-furnace slag sold or used by processors in the United States, by use

(Thousand short tons and thousand dollars)

Use	1972				1973			
	Screened		Unscreened		Screened		Unscreened	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Aggregate in—								
Portland cement concrete construction	2,270	5,296	--	--	2,450	5,882	--	--
Bituminous construction (all types)	4,539	9,503	--	--	5,232	11,442	--	--
Highway and airport construction [1]	8,123	16,945	699	933	9,666	20,790	676	1,022
Manufacture of concrete block	514	1,264	--	--	628	1,567	1	2
Railroad ballast	3,686	5,788	5	7	3,256	5,139	--	--
Mineral wool	665	1,405	39	30	768	1,812	46	35
Roofing slag:								
Cover material	262	730	--	--	299	1,064	--	--
Granules	132	953	--	--	67	530	--	--
Sewage trickling filter medium	41	67	--	--	38	68	--	--
Agricultural slag, liming	6	14	--	--	10	23	--	--
Other uses	730	1,687	167	165	1,278	2,420	556	453
Total	20,968	43,652	910	1,135	23,692	50,737	1,279	1,512

[1] Other than in portland cement concrete and bituminous construction.

Source: National Slag Association.

Table 5.—Granulated and expanded iron-blast-furnace slag sold or used by processors in the United States, by use

(Thousand short tons and thousand dollars)

Use	1972				1973			
	Granulated		Expanded		Granulated		Expanded	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Highway construction and fill (road etc.)	988	1,367	--	--	1,397	1,920	--	--
Agricultural slag, liming	61	130	--	--	64	140	--	--
Manufacture of cement (all types)	444	1,258	226	678	232	1,112	[1] 195	585
Lightweight concrete	--	--	--	--	--	--	25	80
Aggregate for concrete-block manufacture	23	93	1,264	4,766	15	70	1,560	6,105
Other uses	141	211	28	85	291	425	72	166
Total	1,657	3,059	1,518	5,529	1,999	3,667	1,852	6,936

[1] In addition 255,000 tons of air-cooled slag was used in the manufacture of portland cement.

Source: National Slag Association.

Table 6.—Steel slag sold or used by processors in the United States, in 1972, by use [1]

(Thousand short tons and thousand dollars)

Use	1972 Quantity	1972 Value	1973 Quantity	1973 Value
Railroad ballast	1,327	1,430	1,341	1,691
Highway base or shoulders	3,579	3,512	3,241	3,268
Paved-area base	1,779	1,844	1,470	1,499
Miscellaneous base or fill	1,925	2,193	2,263	2,182
Bituminous mixes	563	821	889	1,296
Agricultural	108	324	115	336
Other uses	881	899	420	493
Total	10,162	11,023	9,739	10,765

[1] Excludes tonnage returned to furnace for charge material.

Source: National Slag Association.

PRICES

Iron and steel slag encountered strong price competition from mineral aggregates such as crushed stone and sand and gravel in 1973. Prices of most types of slag were only slightly changed from those of 1972. The unit value of all iron-blast-furnace slag was $2.18 per ton, compared with $2.13 per ton in 1972. Corresponding figures for steel slag were $1.11 per ton in 1973 and $1.08 per ton in 1972.

The price of screened air-cooled blast-furnace slag used for highway and airport construction rose $0.06 to $2.15 per ton, for railroad ballast, up $0.01 to $1.58 per ton, for bituminous construction, up $0.10 to $2.19 per ton, and for portland cement structures, up $0.07 to $2.40 per ton. The price of granulated iron slag used in highway and airport construction, the main use, declined slightly to $1.37 per ton. Prices of steel slag used for highway construction rose $0.03 to $1.01 per ton, for paved areas the price declined $0.02 to $1.02 per ton, and for miscellaneous base and fill, prices declined $0.18 to $0.96 per ton.

Table 7.—Average value of iron-blast-furnace slag sold or used by processors in the United States, by use

(Per short ton)

Use	Air cooled: Screened 1972	Air cooled: Screened 1973	Air cooled: Unscreened 1972	Air cooled: Unscreened 1973	Granulated 1972	Granulated 1973	Expanded 1972	Expanded 1973
Aggregate in—								
Portland cement concrete construction	$2.33	$2.40	--	--	--	--	--	--
Bituminous construction (all types)	2.09	2.19	--	--	--	--	--	--
Highway and airport construction [1]	2.09	2.15	$1.33	$1.51	$1.38	$1.37	--	--
Manufacture of concrete block	2.46	2.50	--	2.00	r 4.04	4.67	$3.77	$3.91
Lightweight concrete	--	--	--	--	--	--	3.03	3.20
Railroad ballast	1.57	1.58	1.40	--	--	--	--	--
Mineral wool	2.11	2.40	.77	.76	--	--	--	--
Roofing slag:								
Cover material	r 2.79	3.56	--	--	--	--	--	--
Granules	r 7.22	7.91	--	--	--	--	--	--
Sewage trickling filter medium	r 1.63	1.79	--	--	--	--	--	--
Agricultural slag, liming	r 2.33	2.30	--	--	2.13	2.19	--	--
Other uses	2.31	1.89	.99	.81	r 2.51	2.94	3.00	3.81

r Revised.
[1] Other than in portland cement and bituminous construction.

Source: National Slag Association.

FOREIGN TRADE

Exports of iron and steel slag totaled 37,117 tons valued at $734,723, a level well above that of 1972. Canada was the principal export market, receiving 94% of the quantity and 28% of the value of total exports. The United Kingdom received 4% of the quantity and 53% of the value. Australia, the Netherlands, West Germany, and Italy were the principal recipients of the remainder.

Imports totaled 1,268 tons valued at $13,914 all of which came from Canada. Imports supply only a very small share of the U.S. market for iron and steel slag.

Table 8.—U.S. exports and imports for consumption of slag, dross and scaling from the manufacture of iron and steel

Country	1972		1973	
	Short tons	Value	Short tons	Value
Imports: Canada	1,455	$16,867	1,268	$13,914
Exports:				
Australia	--	--	271	2,468
Belgium-Luxembourg	279	23,375	--	--
Brazil	7	1,159	--	--
Canada	26,533	95,250	34,768	202,293
Colombia	1	1,738	--	--
Finland	--	--	79	720
Germany, West	26	9,000	100	35,859
Guinea	--	--	106	970
Ireland	--	--	51	1,428
Italy	22	3,400	58	20,743
Kuwait	13	3,436	--	--
Mexico	93	4,749	--	--
Nansei Islands	122	1,110	--	--
Netherlands	131	8,680	140	70,119
Tunisia	--	--	44	4,032
United Kingdom	264	53,235	1,495	388,895
Venezuela	--	--	5	7,196
Total	27,491	205,132	37,117	734,723

WORLD REVIEW

France.—Production of iron-blast-furnaces slag in 1972, the latest year for which detailed statistics are available, totaled 15.1 million tons. Approximately 50% was granulated, 36% was air-cooled; the remainder was utilized either by foaming or deposited in stockpiles. The main uses for granulated slag were in the manufacture of cement, 32%, and in roads and highways, 24%. Approximately 13% was exported, 12% stockpiled, and 8% discarded as waste. Air-cooled slag was used mainly for roads and foundations, 59%, with an additional 19% stockpiled. Both types of slag had many minor uses.

United Kingdom.—Production of iron and steel slag in 1972, the latest year for which data are available, totaled 7.8 million tons. Approximately 72% of the slag was used in road construction; the remainder was used in numerous applications. Of the quantities used in road construction, approximately 58% was used in conjunction with macadam or bituminous materials. More than 96% of the total slag produced was of the air-cooled variety, 3% was foamed, and less than 1% was granulated. Properties, uses, and physical and chemical properties of foamed slag were published.[3]

West Germany.—Production of iron and steel slag in 1972 totaled 11.7 million tons, 50% of which was derived from steel mills. Approximately 80% of that output was used in road building, the remainder for fertilizer, mineral wool, cement, and a few other uses. About 77% of the iron and steel slag was air-cooled, 21% granulated, and 2% foamed.

[3] The British Quarrying and Slag Federation, Ltd. Foamed Slag the Lightweight Aggregate. BQSF, INF 5, March 1973, 4 pp.

Sodium and Sodium Compounds

By Charles L. Klingman [1]

Total production of soda ash (sodium carbonate) in the United States in 1973 was almost exactly the same as that of 1972, but demand continued to increase at least as much as the historic 3% growth rate. Exports of soda ash were reduced by 55,000 tons and for the first time, there was an importation of 16,000 tons of soda ash. Even though the supply-demand imbalance was not large, soda ash market conditions were chaotic in 1973.

Construction continued toward increasing productive capacity at the Trona mines of Wyoming, but the actual increase (about 16%) was limited by shortages of fuel and skilled production workers. The increase in naturally derived soda ash production was practically nullified by a 472,000-ton reduction in synthetic soda ash outlet. Synthetic soda ash plants were plagued in 1973 by shortages and poor quality of raw materials.

There was a 7.6% increase in 1973 in total sodium sulfate production in spite of a loss of 4.1% in the production of naturally derived salt cake. Metallic sodium output showed a 10.2% increase in 1973 as compared with a historic growth rate of about 2.0% per annum.

Legislation and Government Programs.—There has been a depletion allowance, for Federal income tax purposes, on the mining of trona since 1946; but in 1970 the U.S. Internal Revenue Service gave notice that it wanted to end this allowance. In 1973, a proposal to this effect was on the verge of adoption when the proposal was introduced in the Senate which, in effect, guaranteed continuation of the depletion allowance. Although the U.S. Department of the Treasury strongly opposed the amendment, the Wyoming soda ash producers said that the depletion allowance was essential to the continuation of their plans to increase trona production.

Federal price controls on soda ash and other sodium compounds were scheduled to end April 1, 1974.

DOMESTIC PRODUCTION

In 1973 there was a surging demand for soda ash but total production increased by only 0.4%. Therefore, the market was in turmoil throughout the year. The shortfall in soda ash was estimated by one writer to be about 350,000 tons.[2]

Soda ash producers were forced to allocate their output to present customers on the basis of 1972 usage, and new customers had practically no chance to obtain supplies. Prices were regulated under phases 3 and 4 of the Economic Stabilization Act, so there was no opportunity for soda ash users to bid against each other for additional shipments. Small tonnages of European soda ash, amounting to 0.2% of U.S. consumption were imported at prices up to four times the prevailing domestic prices. Greater demand also caused a reduction in exports.

[1] Physical scientist, Division of Nonmetallic Minerals—Mineral Supply.

[2] American Glass Review. Soda Ash Update. V. 94, No. 8, February 1974, pp. 6–7.

Table 1.—Manufactured and natural sodium carbonates produced in the United States

(Thousand short tons and thousand dollars)

Year	Manufactured soda ash (ammonia-soda process) [1] [2]	Natural sodium carbonates [3]		Total quantity
	Quantity	Quantity	Value	
1969	4,540	2,495	50,922	7,035
1970	4,393	2,678	56,320	7,071
1971	r 4,298	2,865	60,774	7,163
1972	r 4,310	3,218	71,689	7,528
1973	p 3,838	3,722	94,385	7,560

p Preliminary. r Revised.
[1] U.S. Bureau of the Census. Current Industrial Reports, Inorganic Chemicals.
[2] Includes quantities used to manufacture caustic soda, sodium bicarbonate, and finished light and dense soda ash.
[3] Soda ash and trona (sesquicarbonate).

Table 2.—Sodium sulfate produced and sold or used by producers in the United States [1]

(Thousand short tons and thousand dollars)

Year	Production (manufactured and natural) [2]			Sold or used by producers (natural only)	
	Lower purity [3] (99% or less)	High purity	Total quantity	Quantity	Value
1969	730	744	1,474	672	12,427
1970	561	812	1,373	598	10,932
1971	514	843	1,357	688	11,008
1972	r 526	801	r 1,327	701	11,396
1973	p 573	848	[4] 1,422	672	11,597

p Preliminary. r Revised.
[1] All quantities converted to 100% Na_2SO_4 basis.
[2] U.S. Bureau of the Census. Current Industrial Reports, Inorganic Chemicals.
[3] Includes glauber salt.
[4] Data does not add to total shown because of independent rounding.

The three producers of natural soda ash at Green River, Wyo., increased their combined output by about 16%, but this was offset by comparable reductions from synthetic soda ash producers. Texas Gulf, Inc., contracted with Stearns-Roger, Inc. of Denver, Colo., to build a fourth soda ash mine and plant near Green River, Wyo. It is scheduled to start producing in 1976. Construction of new facilities for production of natural soda ash was apparently continuing on schedule, but the anticipated increases were not fully realized because of a shortage of skilled production workers and occasional shortages of fuel. Natural soda ash increased to 49.2% of the total production as compared with 42.7% in 1972.

There was a large drop in production of synthetic (Solvay) soda ash. There were no known plant closings during the year, but all plants seemed to be having trouble, especially with raw materials supplies. The anthracite coal or coke used to convert limestone to lime was reported to be in very short supply, was poor in quality, and was higher in price. There were also shortages in fuel for steam generation. Approximately 2.8 tons of steam were required to make one ton of soda ash, so fuel costs made up a significant portion of total production costs. All existing Solvay plants were quite old, so maintenance shutdowns were frequently required, were time consuming, and were expensive. It was believed that some of the existing Solvay plants would close as soon as the present shortage of soda ash eases.

Caustic soda, which was interchangeable with soda ash in certain applications, was also in short supply during 1973. This situation was caused, in part, by the shutdown of some mercury-electrode, chlorine-caustic cells which were under attack by environmentalists for pollution of public water courses. Additional capacity for producing caustic soda was under construction but would not be in full production for 1 or 2 years.

Sodium sulfate, or salt cake, showed a 20.7% increase in production of the synthetic product and a 4.1% decrease in output of the natural sulfate, resulting in an overall increase of 7.6%. Historically, synthetic salt cake production had wide year-to-year variations with no significant growth for more than 20 years. Naturally derived sodium sulfate, on the other hand, displayed an annual growth of about 5%, so the 1973 decrease was disappointing, by comparison. Salt cake derived from natural sources declined to 47.0% of the total output in 1973 compared with 52.8% in 1972. Early in 1973, there seemed to be an ample supply of salt cake, but during the last 2 months of the year demand was apparently greater than supply. This could have been caused by a general tightness in the whole sodium market and more substitution of salt cake for soda ash and caustic soda. There was no lack of source material for natural sodium sulfate in the western part of the country.

Metallic sodium output increased to 176,903 tons, an alltime record and 10.6% above the 1972 production. This was a surprise development, since the historic growth rate was only 2.0% per annum; in addition, over 80% of the metallic sodium was utilized in the manufacture of a compound which was supposed to be on the decrease, tetraethyl lead, a gasoline additive.

A list of U.S. producers of natural sodium compounds and metallic sodium follows:

Product	Company	Plant location	State	Source of sodium
Soda ash	Kerr-McGee Chemical Corp	Trona	California	Dry lake brine.
Do	Stauffer Chemical Co	Westend	do	Do.
Do	Allied Chemical Corp	Green River	Wyoming	Underground trona.
Do	FMC Corp	do	do	Do.
Do	Stauffer Chemical Co	do	do	Do.
Sodium sulfate	do	Trona	California	Dry lake brine.
Do	Kerr-McGee Chemical Corp	do	do	Do.
Do	United States Borax & Chemical Corp.	Boron	do	Open pit mining.
Do	Ozark-Mahoning Co	Brownfield	Texas	Subterranean brine.
Do	do	Seagraves	do	Do.
Do	Great Salt Lake Minerals & Chemicals Corp.	Ogden	Utah	Salt lake brine.
Metallic sodium	E.I. du Pont de Nemours & Co.	Niagara Falls	New York	Salt.
Do	do	Memphis	Tennessee	Do.
Do	Ethyl Corp	Baton Rouge	Louisiana	Do.
Do	do	Houston	Texas	Do.
Do	Reactive Metals Inc	Ashtabula	Ohio	Do.

CONSUMPTION AND USES

The Bureau of Mines does not routinely survey consumers of sodium compounds (except salt), so data on utilization of these products were indirectly obtained from production data on related commodities or from the studies made by other agencies. For example, data on production of glass sand indicated that there was an increase in glass output and from the figures it could be calculated that 51.5% of the total soda ash production went to the making of glass. The higher glass output might have been caused by an increase in the manufacture of expendable (nonreturnable) bottles. Shortages of paper and plastic for containers could have required more glass for this end usage.

Required reductions in the phosphate content of dry detergents in 1973 created an additional outlet for sodium sulfate in these powdered products. In this usage sodium sulfate is not claimed to improve the cleaning characteristics of the detergents but is merely a low-priced extender or diluent for the concentrated detergent. Also, with a decrease in availability of caustic soda and soda ash for the manufacture of pulp and paper, more salt cake might have been required for this specific usage.

Increases in production of tetraethyl and tetramethyl lead did not keep pace with the increased output of metallic sodium, so it might be inferred that the portion of metallic sodium used in tetraethyl and tetramethyl lead manufacture dropped from 83% in 1972 to about 80% in 1973. It also followed that other uses for metallic sodium such as detergent manufacture and the reduction of metallic ores increased.

As far as is known, the remaining usages of sodium compounds remained about the same in 1973 as they were in 1972.

TRANSPORTATION

With the shift in soda ash output from that manufactured at plants in the northeast, to that recovered from natural deposits in the far west, transportation and its costs took on increasing significance for soda ash users. There was only one important route for the movement of soda ash from Green River, Wyo., and that was by Union Pacific Railroad. A railroad strike, a shortage of rail cars, or major equipment failure could virtually shutdown the soda ash industry. If the production could be handled by truck, over 1,000 trucks per day or 42 trucks per hour, each with a 20-ton load, would be required.

A novel soda ash transportation plan was considered by producers. The plan called for a pipeline to convey a water slurry of soda ash from Green River, Wyo., to some central distribution point in the northeast, possibly on a navigable waterway. The pipeline would have to be more than 1,000 miles long and would be expensive, but once installed, would reduce shipping costs, including handling at both ends by perhaps 25%.

PRICES

Market prices quoted at yearend for sodium carbonate, sodium sulfate, and metallic sodium were as follows:

	1972	1973 [1]
Sodium carbonate (soda ash):		
Light, paper bags, carlots, works ____per 100 pounds__	\$2.47½	\$2.47½
Light, bulk, carlots, works ____do____	1.77½	1.77½
Dense, paper bags, carlots, works ____do____	2.47½	2.47½
Dense, bulk, carlots, works ____do____	1.77½	1.77½
Sodium sulfate (100 percent Na_2SO_4):		
Technical detergent, rayon grade, bags, carlots ____per ton__	43.00–46.00	43.00–46.00
Technical detergent, rayon-grade, bulk, works ____do____	33.00	33.00
Domestic salt cake, bulk, works [2] ____do____	28.00	28.00
National Formulary (N.F. XII), drums ____per pound__	.23½	.23½
Metallic sodium:		
Bricks, carlots, works ____do____	.30	.30
Fused, lots 18,000 pounds and more, works ____do____	.26½–.27½	.26½–.27½
Bulk, tank, works ____do____	.18¾	.18¾

[1] Chemical Marketing Reporter. Current prices of chemicals and related materials. V. 204, No. 27, Dec. 31, 1973.
[2] East of Mississippi River; price in the west is \$18.50 per ton, f.o.b. producing point.

FOREIGN TRADE

In 1973, exports of soda ash dropped to 425,000 tons or 5.6% of production, from 480,000 tons or 6.4% of production in 1972. In 1973, there was also a small import of soda ash for the first time, which reduced net exports to 409,000. Over half of the soda ash exported went to Canada and Mexico and over one-fourth was shipped to South American countries. The soda ash imports came almost entirely from European countries.

In sodium sulfate, the United States imported 320,000 tons or 18.9% of domestic total consumption but exported 45,000 tons or 2.7% of the total consumption. The net importation was, therefore 275,000 tons or 16.2% of consumption. These figures are quite similar to those of 1972 except that salt cake exports were slightly higher in 1973. Canada supplied about 48.0% of the imports; Belgium-Luxembourg 41.5%; West Germany 4.5%; East Germany 2.9%; and 3.1% other countries.

The value of exports of all sodium compounds exceeded the value of the imports by 11.4 million.

Tariff rates for sodium compounds remained constant throughout the year as shown by the following tabulation:

	Tariff Jan. 1, 1973 (dollars per short ton)
Sodium carbonate:	
Calcined (soda ash)	2.40
Hydrated and sesquicarbonate	2.00
Sodium sulfate:	
Crude (salt cake)	Free
Anhydrous	.25
Crystallized (glauber salt)	.50

Table 3.—U.S. exports of sodium carbonate and sodium sulfate

(Thousand short tons and thousand dollars)

Year	carbonate Sodium		Sodium sulfate	
	Quantity	Value	Quantity	Value
1971	437	15,400	66	1,825
1972	480	[r] 18,911	29	926
1973	425	16,064	45	2,049

[r] Revised.

Table 4.—U.S. imports for consumption of sodium sulfate

(Thousand short tons and thousand dollars)

Year	Crude (salt cake) [1]		Anhydrous		Total [1]	
	Quantity	Value	Quantity	Value	Quantity	Value
1971	236	4,108	32	559	268	4,667
1972	226	4,082	73	1,275	299	5,357
1973	240	4,054	80	1,602	320	5,656

[1] Includes glauber salt as follows: 1971, none; 1972, 50 long tons ($1,491); 1973, 98 long tons ($2,200).

Table 5.—U.S. imports for consumption of sodium carbonate and bicarbonate in 1973

(Thousand short tons and thousand dollars)

	Quantity	Value
Soda ash	10	756
Sodium bicarbonate	6	260
Total	16	1,016

WORLD REVIEW

Argentina.—The Government of Argentina has exercised controls over the exportation of goods to conserve materials for local utilization if they are in short supply. Specifically mentioned in the order were carbonate and bicarbonate of soda.[3]

The 1971 production of sodium sulfate (mirabilite) was 21,700 short tons.[4] Production in 1973 was estimated at 40,000 tons.

Canada.—Salt cake production in 1973 was 525,000 tons, an increase of 3.6% over that of 1972. Canada consumed 81% of its production, 90% of which went to the making of pulp and paper. The portion going into the manufacture of synthetic detergents however, showed the largest gain. Exports, primarily to the United States, increased 12%. Production for 1974 was predicted to be about 10% above the present rate.

Six producers of natural salt cake in Saskatchewan and Alberta produced 92%

[3] U.S. Embassy, Buenos Aires, Argentina. State Department Telegram, Feb. 15, 1974, p. 1.

[4] U.S. Embassy, Buenos Aires, Argentina. State Department Airgram A-240, May 17, 1973, p. 1.

of the country's output. Three smaller companies produced synthetic or byproduct salt cake in Ontario and Nova Scotia. There were two synthetic soda ash plants in Canada, one in Manitoba and one in Ontario. A new chlorine-caustic plant rated at 65,000 tons of caustic soda per year was being built at Becaneour, Quebec. It is scheduled to be onstream by spring 1975.

Chad.—Lake Chad was a good potential source of trona (termed "natron" in reports from Chad), but the 1973 production from this source was only 7,000 tons. The material was collected by hand from incrustations around the naturally alkaline lake and was continually replaced by solar evaporation of the lake water. Modern extraction equipment and rail transportation were necessary for large-scale exploitation of this source of soda ash.

Chile.—Sodium sulfate production figures for 1972 were published during 1973[5] and are as follows in short tons:

From natural sources	5,413
From the nitrate industry	40,938
Total	46,351

The government-owned nitrate monopoly announced that, it hoped to spend $32.3 million on updating the equipment and plants for producing various chemicals, among them sodium sulfate.[6]

The Central Bank of Chile devalued the bankers rates for selected exports and imports. The list included sodium sufate.[7]

Japan.—All of the soda ash produced in Japan was synthetic rather than natural, but its volume, 1,374,000 tons in 1973,[8] made it a large contributor to world supply. In spite of this large production, soda ash was in short supply in Japan in 1973. Increase in capacity of the Solvay plants was not planned, but importation of naturally derived soda ash from Wyoming was anticipated.

Kenya.—There were extensive trona deposits at Lake Magadi and the 1973 production was estimated at 197,000 tons. Only 16% of this was consumed in Africa and the rest was exported primarily to India, Japan, and the Philippines. The company which extracted the trona was called the Lake Magadi Soda Company Ltd., and was a subsidiary of the British firm, Imperial Chemical Industries, Ltd. (ICI). The raw material from the lake was calcined in Kenya before shipment. Trona reserves in Lake Magadi were estimated at 100 million tons.

Mexico.—The apparent consumption of soda ash in Mexico in 1973 was estimated to be 453,100 short tons. There were two soda ash plants in Mexico and a third being planned at Pajaretos, Vera Cruz.

United Kingdom.—A strike of British coal miners had a direct effect on United Kingdom soda ash output since coal, reduced to coke, was used in calcining limestone to reagent lime for the production of soda ash. The cutback was about 25% of the previous rate, and this had a "domino effect" on the glass and paper industries and subsequently on all products which were packaged in paper or glass. Little relief was obtained from abroad because of the worldwide shortage of soda ash.[9]

The sodium bicarbonate industry of England operated at nearly full capacity throughout 1973.[10]

The Mond Division of ICI, announced a modernization program of its 47-year-old Solvay soda ash works at Northwich, Cheshire. Total expenditure was reported to be £3.25 million ($7.7 million U.S.)[11]

TECHNOLOGY

The Japanese have devised and brought onstream a full-scale plant for producing metallic sodium by an improved method.[12] The process features reduced cost because of (1) lower operating temperature; (2) higher current efficiency; (3) lower labor costs; and (4) almost complete elmination of corrosion. The process starts by the creation of a sodium amalgam in a mercury-electrode electrolytic cell in which brine, instead of fused sodium chloride, is the electrolyte. The sodium amalgam is then transferred to a second cell in which this alloy is used as the anode and a perforated iron plate is

[5] U.S. Embassy, Santiago, Chile. State Department Airgram A-92, May 9, 1973, p. 1.
[6] U.S. Embassy, Santiago, Chile. State Department Airgram A-38, Feb. 15, 1974, p. 1.
[7] U.S. Embassy, Santiago, Chile. State Department Telegram, June 4, 1973, p. 1.
[8] Suzuki, Sentaro. Soda Products. Japan Chemical Review, 1974. December 1973, p. 60.
[9] Chemical Age. Coke Scarcity Forces ICI Soda Ash Cut-Back. Mar. 1, 1974, p. 8.
[10] Chemical Marketing Reporter. From the Cable Desk—Sodium Bicarbonate (Britain). V. 204, No. 12, Sept. 17, 1973.
[11] Chemical Marketing Reporter. Soda Ash Plant of ICI Slated for Modernization. V. 203, No. 20, May 14, 1973, p. 29.
[12] Nakamura, T., and Y. Fukuchi. Tekkosha's New Metallic Sodium Process. J. Metals, v. 24, No. 8, August 1972, pp. 25-27.

used as the cathode. The second electrolyte is a mixture of fused caustic soda, sodium iodide, and sodium cyanide held at a temperature of about 230° C (446° F) and kept under an atmosphere of hydrogen. The metallic sodium is drawn off continuously and is purified to remove the traces of mercury. Metallic mercury is, of course, recovered and recirculated back to the first electrolytic cell.

Table 6.—Sodium carbonate and sodium sulfate: World production by country [1]

(Thousand short tons)

Commodity and country	1971	1972	1973 p
Sodium carbonate:			
Natural:			
Chad	8	NA	8
Kenya	178	164	217
Sudan [2]	160	52	e 50
United States [3]	2,865	3,218	3,722
Total	3,211	3,434	3,997
Manufactured:			
Belgium	344	e 350	e 350
Brazil e	120	130	140
Bulgaria	332	e 340	e 340
Chile e	11	11	11
Colombia e	22	22	22
Czechoslovakia	126	133	e 138
Denmark	1	e 1	e 1
France	1,566	1,573	1,685
Germany, East	787	e 825	e 880
Germany, West	1,489	1,540	1,567
Greece	(4)	e 1	e 1
India	528	536	488
Italy	732	e 733	e 740
Japan	1,409	e 1,430	e 1,480
Mexico	352	e 355	e 355
Netherlands [5]	266	284	e 275
Norway	23	e 28	e 28
Pakistan	89	75	84
Poland	737	e 750	e 770
Portugal	53	105	e 110
Romania	662	733	e 750
Spain	382	415	e 420
Sweden	1	e 1	e 1
U.S.S.R.	4,185	4,184	4,519
United States	4,298	4,310	3,838
Yugoslavia	116	129	142
Total	18,631	18,994	19,135
Sodium sulfate, natural:			
Argentina	22	e 25	e 28
Canada	482	507	525
Chile	8	5	e 6
Iran	19	20	e 21
Mexico	146	141	192
Spain	144	139	e 140
Turkey	20	33	e 33
United States	688	701	672
Total	1,529	1,571	1,617

e Estimate. p Preliminary. NA Not available.
[1] Table includes data on production of both natural and manufactured sodium carbonate and natural sodium sulfate; worldwide data on manufactured sodium sulfate production are not sufficiently complete for this category to be added to the table.
[2] Production is not reported; figures presented represent exports.
[3] Sold or used by producers.
[4] Less than ½ unit.
[5] Production for sale only; excludes output consumed by producers.

Stone

By Harold J. Drake [1]

Production of stone in 1973 totaled 1.1 billion tons valued at $2 billion. The quantity and value were 15% and 19%, respectively, above those of 1972. Most of the rise was attributed to increased output; a lesser share was due to expanded coverage of the crushed stone industry. Production of crushed stone totaled 1.06 billion tons valued at $1.9 billion compared with 919 million tons valued at $1.6 billion in 1972. Approximately 69% was used for construction aggregate, 11% for cement manufacture, 4% for agricultural purposes, and 3% for flux stone. Production of dimension stone rose 6% in quantity to 1.6 million tons but declined 5% in value to $86.0 million. Production of granite rose 15%, and sandstone, quartz, and quartzite, 28%, whereas production of marble was off 32%, and limestone and dolomite declined 10%.

Crushed stone was produced in every State except Delaware. Principal producing States were California, Illinois, Florida, Texas, Ohio, and Missouri, which, in the aggregate, produced 32% of the total U.S. output. Dimension stone was produced in 44 States with Georgia, Indiana, Ohio, Pennsylvania, and Vermont accounting for 55% of the total. Massachusetts, Minnesota, and Wisconsin also accounted for large tonnages.

Price changes for stone were mixed in 1973. The average unit value for all crushed stone rose $0.08 to $1.80 per ton. The corresponding figure for dimension stone was $54.36, off $6.55 per ton. The value of imports of stone was up 12% while that of exports was up 18%.

Legislation and Government Programs.—The National Science Foundation (NSF) announced plans to conduct a study of the crushed stone industry to determine the possibility of applying the sophisticated technology of the aerospace industry to traditional industries. The study will be conducted for NSF by the National Crushed Stone Association, Washington, D.C., and Martin Marietta Corp., Baltimore, Md. In the 1972 National Limestone Institute Safety Competition, top safety honors were awarded to Suwannee Mine, Florida Rock Industries, Inc., Live Oak, Fla.; Monroe Quarry, The France Stone Co., Monroe, Mich.; Pitts Quarry, Pitts Quarry Inc., Ashley, Ill.; Custar Mine, Pugh Quarry Co., Custar, Ohio; and Hillview Quarry and Volstad Quarry, Martin Volstad, Carrollton, Ill. These operations had the best safety records in the five categories of plants comprising the contest conducted by the Bureau of Mines, U.S. Department of the Interior, in cooperation with the National Limestone Institute.

[1] Physical scientist, Division of Nonmetallic Minerals—Mineral Supply.

Table 1.—Salient stone statistics in the United States [1]
(Thousand short tons and thousand dollars)

	1969	1970	1971	1972	1973
Shipped or used by producers:					
Dimension stone	1,867	1,565	1,626	1,490	1,582
Value	$98,547	$95,157	$93,132	$90,763	$85,999
Crushed stone	861,021	867,628	874,497	r 918,933	1,058,541
Value	$1,326,047	$1,374,441	$1,500,933	r $1,581,530	$1,904,464
Total stone [2]	862,889	869,193	876,123	r 920,423	1,060,124
Value [2]	$1,424,594	$1,469,598	$1,594,065	r $1,672,293	$1,990,463
Exports (value)	$10,223	$10,396	$11,489	$11,107	$13,063
Imports for consumption (value)	$30,548	$35,674	$33,643	r $43,436	$48,678

r Revised.
[1] Includes slate.
[2] Data may not add to totals shown because of independent rounding.

DIMENSION STONE

DOMESTIC PRODUCTION

Production of dimension stone in 1973 increased 6% in quantity but declined 5% in value from the 1972 levels. The advance in volume was attributed to increased construction activity. Output totaled 1.6 million tons valued at $86.0 million. Production of granite totaled 713,000 tons valued at $46 million, rises of 15% in quantity and 8% in value from the preceding year. Dimension limestone and dolomite recorded declines of 10% and 17% in quantity and value, respectively, to 370,000 tons valued at $11.9 million. Production of sandstone, quartz, and quartzite was up 28% in quantity and 10% in value to 296,000 tons valued at $8.4 million. Production of marble totaled 48,000 tons valued at $10.1 million compared with 71,000 tons valued at $16.5 million in 1972. Production of slate rose both in quantity and value whereas that of other types of dimension stone fell 3% in quantity and 21% in value.

CONSUMPTION AND USES

Apparent consumption of dimension stone was valued at $125 million, a level virtually unchanged from the preceding year. A decline in value of domestically produced stone was offset by a 12% increase in the value of imports. The share of the U.S. dimension stone market supplied by U.S. producers was 67%.

In 1973, the domestic market for dimension stone, in terms of value, was divided into 44% granite, 10% limestone and dolomite, 23% marble, 7% sandstone, quartz, and quartzite, and 16% slate and other dimension stone. Apparent consumption of granite totaled $54.5 million, up 5%, and that of marble was $28.6 million, down 12%. Considerable quantities of these kinds of dimension stone are also imported annually. Consumption of limestone and dolomite was valued at $11.5 million, off 20%, and that of sandstone, quartz, and quartzite totaled $8.4 million, up 10%. U.S. producers normally supply the great bulk of these types of stone. Consumption of slate and other kinds of stone rose 11% and 17%, respectively, from the levels of 1972.

The principal uses for domestically produced rough dimension stone were in monumental, architectural, and construction applications. Consumption of monumental stone totaled $12.3 million, that of architectural stone, $6.5 million, and that of construction stone $4.1 million. The remainder went for flagstone and numerous other uses. Consumption of domestically produced dressed stone was valued at $61.5 million, most of which consisted of cut stone ($20.7 million) and monumental stone ($14.2 million). The value of sawed stone totaled $4.5 million. Consumption of dressed house stone veneer was valued at $3.5 million, curbing, at $7.8 million, and roofing and millstock slate, at $5.1 million. The remainder was used principally in construction and flagging.

PRICES

Average values for dimension stone in 1973, as reported to the Bureau of Mines, were as follows, in dollars per ton:

	Building		Monumental, rough and dressed	Flagging
	Rough	Dressed		
Granite	$32.12	$ 86.55	$63.70	--
Marble	54.29	290.24	--	--
Limestone	19.15	51.61	--	$21.50
Sandstone	18.16	50.19	--	39.33
Slate	--	145.43	--	34.77
Miscellaneous	14.42	60.57	--	--

FOREIGN TRADE

U.S. exports of dimension stone declined 5% to $2.8 million. The export market has not been a significant outlet for U.S. producers and in 1973 accounted for only 3% of their output. Canada and countries in South America such as Venezuela and Chile have been the principal foreign markets.

Imports of dimension stone supplied a significant share of the U.S. market for dimension stone. In 1973, imports were valued at $41.5 million, compared with $37.4 in 1972, and supplied 33% of the U.S. market. Increased shipments were recorded for marble, at $18.5 million; travertine, at $3.3 million; slate, at $6.5 million; other stone, at $4.5 million; and limestone at $188,000. Imports of granite, however, declined 9% to $8.6 million. Imports of marble and travertine, which accounted for 45% of the total value of imports, rose 14%, slate rose 15%, and miscellaneous stone rose 40%. The principal marble item, slabs and paving tiles, rose 20%. Imports of whiting rose 57% to $1.2 million.

As in past years, Italy and Portugal supplied most of the marble and travertine imports. Granite was imported principally from Italy and Canada. Numerous other countries supplied the remainder.

WORLD REVIEW

Greece.—An estimated 400 to 500 quarries operated by 250 companies produced marble in 1973. Production has averaged about 200,000 tons in recent years and is expected to be three times greater by 1980. Most of the marble produced goes to the building industry as dimension stone, but some was ground.

United Arab Emirates.—Marble was produced in the Emirate of Ajman not far from the town of Ajman. Output totals about 60 square yards per day but is expected to double during 1974. All of the output is used locally.

CRUSHED STONE

DOMESTIC PRODUCTION

Production of crushed stone in 1973 totaled 1.06 billion tons valued at $1.9 billion compared with 919 million tons valued at $1.6 billion in 1972. The new high in output was attributed in part to increased demand and in part to expanded coverage of crushed stone producers.

The sharp gain in total production was led by limestone and dolomite, which increased 15% in quantity and 21% in value. Granite also recorded sharp production gains of 13% and 19% in quantity and value, respectively. Production of traprock rose 9% in quantity and 11% in value, corresponding figures for sandstone, quartz, and quartzite were 13% and 20%. Other types of stone, which accounted for a lesser portion of total output also recorded gains in output. In quantity and value, shell was up 20% and 27%, respectively, and other stone was up 64% and 89%, respectively. In contrast, marble was off 10% and 6% in quantity and value, respectively, and output of marl was off 12% in quantity and 15% in value.

Domestic producers have encountered some difficulties in meeting the heavy demand in recent years for crushed stone. Shortages in labor and of transportation vehicles were common, and high interest rates have delayed construction of new facilities. Zoning laws and conformance with environmental regulations have served, in many instances, to restrict production.

The problems inherent in the steadily increasing demand for crushed stone must be reconciled with societal demands for environmental quality.[2] Rapid growth and technological development in recent years have created a need for careful internal appraisal of the industry and its place in society. Management science in planning, operating, and evaluating operations in the aggregate industry is a step in this direction.[3] In addition, it is essential to differentiate costs that comprise fixed capital and working capital and how to understand the functions of depreciation for fixed assets.[4]

Several studies were made of the utilization of alternative materials and waste materials for aggregate purposes.[5] Successful utilization of a depleted gravel pit as a sanitary landfill operation may lead one company to utilize an abandoned rock quarry in a similar manner.[6] Key to the success of the operation was the use of a thin layer of asphalt pavement that prevented liquids from permeating into surrounding soils. Perhaps one of the most significant decisions facing crushed stone producers is land reclamation when quarries are depleted. Early planning for industrial or residential use of mined-out areas can lead to considerable savings in time and money.[7]

A number of new plants were planned or opened and numerous existing plants underwent modernization and expansion. Ivy Corp., Atlanta, Ga. announced plans for construction of a major new plant and the expansion of existing operations in

[2] Fish, B. G. Towards a Strategy for Quarrying. Quarry Managers' J., v. 57, No. 8, August 1973, pp. 275–280.
[3] Romani, R. V. Aggregate Industry and the Management Sciences. Pit & Quarry, v. 66, No. 3, September 1973, pp. 107–109, 119.
[4] Holland, F. A., F. A. Watson, and J. K. Wilkinson. Capital Costs and Depreciation. Chem. Eng., July 1973, pp. 118–121.
[5] Building Research Establishment. Report of Aggregates and Waste Materials Working Group. Current Paper 31–73, November 1973, 12 pp.
Gutt, W. Aggregates From Waste Materials. Building Research Establishment. Current Paper 14–72, August 1972, 10 pp.
[6] Hill, A. D. Pave Old Gravel Pit-Town Gets Sanitary Land Fill. Roads and Streets, v. 116, No. 8, p. 104.
[7] Stearn, E. W. Put Your Land to Work—Twice. Rock Products, v. 77, No. 4, April 1974, pp. 46–49.

northern Georgia. A new plant opened by Melvin Stone Co., Melvin, Ohio, reportedly uses 40% less labor than its old plant.[8] Erie Stone Co. modernized its crushed stone plant at Huntington, Ind., and now produces over 1 million tons per year of crushed limestone.[9] Other plant expansions were reported by Maule Industries, Inc., Miami, Fla., Southern Illinois Stone Co., Buncombe, Ill., Marblehead Lime Co., Gary, Ind., Florida Mining and Materials Co., Brookville, Fla., and MCQ Industries, Inc., Columbus, Ohio.

Portable crushed stone plants were used widely by the industry. Ivey Construction Co., Mineral Point, Wis., used a 300-ton-per-hour portable crushing and screening plant to service 10 quarries.[10] V. H. Collender Co., Pittsfield, Ill., used a completely roadable crushing and screening plant to supply as much as 900,000 tons of crushed limestone per year from several quarries.[11] Nesbitt Contracting Co., Mesa, Ariz., mounted crushers and screens on a semitrailer frame and, along with other portable equipment, services as many as a dozen different quarries in a year.[12] Gilpatrick Construction Co., Inc., Riverton, Wyo., used specially designed portable equipment to operate at numerous sites.[13]

Gordon H. Ball, Inc., Black Butte, Calif., used a portable plant to process volcanic lava for use as a construction aggregate.[14] Monitoring of portable plants was accomplished using an airplane and a helicopter.[15] One of California's largest aggregate producers. Livingston-Graham, Inc., El Monte, Calif., used a minicomputer-based information-control subsystem to improve profits and the utilization of equipment and manpower.[16]

CONSUMPTION AND USES

Apparent consumption of crushed stone in 1973 totaled 1.06 billion tons valued at $1.9 billion. Consumption was equivalent to production inasmuch as imports and exports were about equal. Consumption of limestone and dolomite totaled 774 million tons valued at $1.3 billion, while that of granite totaled 121 million tons valued at $216.9 million. Comparable data for 1972 for limestone and dolomite were 672 million tons valued at $1.1 billion, and for granite, 106 million tons valued at $182.9 million. Consumption of traprock totaled 84 million tons valued at $177.7 million, up from 77 million tons valued at $159.8 million in 1972. In the aggregate, these three types of crushed stone accounted for 92% of total consumption. Consumption of marl totaled 2.3 million tons valued at $3.0 million, marble, 2 million tons valued at $23.4 million, and other kinds of stone, 23.5 million tons valued at $46.2 million. Consumption of shell increased to 19.9 million tons valued at $37.6 million.

Construction continued to be the principal market for crushed stone. In 1973, approximately 735 million tons, two-thirds of total consumption, was used as aggregate. Roadbase stone accounted for 258 million tons, concrete aggregate, 153 million tons, bituminous aggregate, 102 million tons, and unspecified aggregate, 130 million tons. Consumption in each of the major use categories was well above 1972 levels. Other major uses, apart from aggregate use, recording consumption gains were cement, at 115 million tons, up 6%, agriculture, at 39 million tons, up 39%, lime manufacture, at 34 million tons, up 13%, and fluxstone at 29 million tons, up 12%. The great majority of all other use categories recorded consumption gains.

PRICES

Quotations in Engineering News-Record for carload lots of 1½-inch crushed stone in 1973, exclusive of discounts, ranged from $6.60 per ton in Minneapolis, Minn. and Los Angeles, Calif., to $1.65 per ton in Birmingham, Ala. The average price reported for 12 major cities was $3.44 per ton. Prices for ¾-inch crushed stone ranged from $6.60 per ton in Minneapolis

[8] Trauffer, W. E. Economy, Capacity, Environmental Control Improved by New 400-TPH Plant of Melvin Stone Company, Pioneer Ohio Crushed Stone Producer. Pit and Quarry, v. 66, No. 5, November 1973, pp. 128–132.

[9] Robertson, J. L. Century-Old Quarry Produces A Million Tons/Year. Rock Products, v. 76, No. 8, August 1973, pp. 40–43.

[10] Robertson, J. L. Portable Plant Serves 10-Quarry Operations. Rock Products, v. 76, No. 8, August 1973, pp. 36–37.

[11] Roads and Streets. Roadable Aggregate Plants Pay Off for Contractor. V. 116, No. 3, March 1973, pp. 251–255.

[12] Roads and Streets. Small Crushing Plant Managed for Full Productivity. V. 116, No. 3, March 1973, pp. 256–257.

[13] Roads and Streets. Inventive Firm Builds Business Around Aggregates Supply. V. 116, No. 3, March 1973, pp. 248–250.

[14] Robertson, J. L. Portable Plant Processes Volcanic Deposit. Rock Products, v. 76, No. 9, September 1973, pp. 46–48.

[15] Robertson, J. L. Aircraft Help Monitor Portable Plants. Rock Products, v. 76, No. 9, September 1973, pp. 43–45.

[16] Modern Office Procedures. A Subsystem for Profit Improvement. V. 18, No. 9, September 1973, pp. 37–40.

to $1.65 per ton in Birmingham. The average price for 12 major cities was $3.51 per ton. Prices per ton for industrial fillers and extenders, as reported in the American Paint Journal, were as follows, in dollars:

Silica, amorphous, ultrafine-ground	$69.00
Silica, crystalline	20.50–45.40
Whiting precipitated, surface-treated	48.00
Whiting, dry-ground 325 mesh	14.25–22.00
Whiting, precipitated, U.S.P	50.00–117.00
Whiting, precipitated, technical	33.00–44.00
Whiting, natural, water-ground	39.00

FOREIGN TRADE

Exports of crushed stone in 1973 totaled 3.1 million tons valued at $10.2 million, increases of 11% and 26%, respectively, from the levels in 1972. An increase in shipments of crushed limestone was partially offset by a decline in shipments of other stone. Canada was the principal market with smaller volumes going to countries in Central America.

Imports of crushed stone rose slightly in 1973 to 3.3 million tons valued at $5 million. Of the two principal kinds of stone comprising imports, crushed limestone declined 6% in quantity, and other crushed stone rose 15% in quantity. Imports of dry-ground whiting rose 28% in quantity and 41% in value to 26,653 tons valued at $875,000. Precipitated chalk whiting totaled 3,332 tons valued at $332,000 compared with 1,895 tons valued at $150,000 in 1972.

WORLD REVIEW

Canada.—Production of crushed stone has averaged about 74 million tons valued at $95 million in recent years. Approximately 88% of the total output was limestone; 6%, granite; and 4%, sandstone. The remainder consisted principally of marble, shale, and slate. Roadstone accounted for about 30% of the total output, concrete aggregate about 15%, asphalt aggregate about 9%, and riprap about 3%. A large number of applications accounted for the remainder. Limestone resources of the Province of Alberta were examined, and it was determined that abundant reserves of high-calcium limestone exist in various parts of the Province.[17]

Dominican Republic.—Aluminum Company of America (Alcoa) joined with local business interests to form a company, Complejo Industrial Pedernales, to produce agricultural lime. Initial production, expected in early 1974, will total 60,000 tons. The limestone raw material will be supplied by Alcoa from its mine in Cabo Rojo.

Japan.—Limestone deposits of good quality are widely distributed throughout Japan. Resources were estimated to be about 41 billion tons with an additional 987 million tons of dolomite.[18] In 1972, the latest year for which detailed statistics were available, 277 companies operated 324 quarries and produced 140 million tons of limestone. Of this production, 61% was used in the manufacture of cement; 18%, for flux; 11%, as aggregate; and 6%, for the manufacture of lime. Numerous other uses accounted for the remainder.

South Africa, Republic of.—Coedmore Quarrier, Durban, Natal, in 1973 completed 50 years of crushed stone production.[19] Production, which consisted of quartzite, dolerite, and tillite, was used as concrete aggregate and coarse aggregate for road work. Production in 1972 was about 1.1 million tons.

United Kingdom.—Production of crushed stone aggregate in Great Britain totaled 110 million tons in 1972. Of this tonnage, 35% was used for fill and ballast, 28% for uncoated roadstone, 19% for concrete aggregate, and 18% for coated roadstone. Production of crushed limestone at the Tunstead Quarry owned by Imperial Chemical Industries, Ltd., exceeded 5.5 million tons a year.[20] High-calcium lime was produced for use in ammonia-soda plants and in the manufacture of lime and cement, but lower quality stone was used for roadstone and aggregate.

Amey Roadstone Corporation, Ltd., more than doubled capacity at its Black Rock Quarry near Portishead, Somerset, to 400,000 tons per year.[21] Redland Roadstone, Ltd., and Hoveringham Stone, Ltd., joined together to form R. H. Roadstone, Ltd., to quarry, process, and market dry and coated stone near Nunney, Somerset.[22]

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[17] Holter, M. E. Limestone Resources of Alberta. Can. Min. and Met. Bull., v. 66, No. 731, March 1973, pp. 140–152.

[18] The Institute of Limestone Quarry. Limestone Mining Industry in Japan. 1973, 5 pp.

[19] Holz, P. South African Quarry Is Modern Efficient. Rock Products, v. 76. No. 10, October 1973; pp. 44–46.

[20] Ironman, R. Tunstead Quarry: Largest Outside of U.S. Rock Products, v. 76, No. 4, April 1973, pp. 70–76.

[21] The Quarry Managers' Journal. Plant Extensions at a Somerset Limestone Working. V. 57, No. 6, June 1973, pp. 193–198.

[22] The Quarry Managers' Journal. Redland Hoveringham Form Joint Limestone Company. V. 57, No. 10, October 1973, p. 363.

TECHNOLOGY

A study of surveying techniques in the quarrying industry was published.[23] A wide range of methods relating to various situations were outlined to demonstrate the usefulness of minerals surveying. The importance of surge piles between the quarry-primary crushing operation and the remainder of the plant was thoroughly discussed.[24]

It was suggested that an appropriate strength test be employed in conjunction with polished-stone value to determine the suitability of crushed stone as paving aggregate.[25] The aggregate impact test was believed to be the best strength and durability test to use inasmuch as it is simple, rapid, and inexpensive yet is sensitive to variations in fundamental properties of the aggregate. Crushed stone was used to stabilize highway subgrade thus enabling the contractor to use the subgrade as a haul road.[26] The crushed stone was thoroughly mixed with silty, unstable subgrade soil and compacted to form a solid impervious foundation that could be used, prior to paving, as a haul road.

Benefits derived from recycling concrete and asphalt rubble in California included lower costs, saving scarce landfill areas, and extending existing aggregate resources.[27] A method of pelletizing ground limestone, using special clay binders, was developed to allow agricultural limestone to be spread evenly and utilized immediately.[28]

Quarry blasting was the subject of a number of studies. One study developed the basic principles, significant variables and procedures for their integration in designing primary blasts from a widely variable combination of possibilities to achieve safe working and economic production.[29]

Generally accepted rules of thumb on blasting in the quarrying industry and their relationship to hole size and pattern were outlined.[30] More precise blasting designs and patterns were presented to provide quarry operators with an uncomplicated, first-approximation method for designing blast patterns.[31] In southern Florida, a high water table and drilling difficulties led to the development of a unique explosives-loading technique.[32] A metal tube slides down the borehole as it is drilled and remains there until the explosives are loaded, after which it is removed.

Guidelines were set out for selecting primers when blasting with AN-FO.[33] Dewatering of blastholes and the cost reductions inherent thereto were examined.[34]

Factors affecting equipment selection and maintenance were reviewed.[35] Use of hydraulic excavators in quarrying operations has expanded considerably in recent years and real benefits have been gained from their use.[36]

Rippers were used to break up deposits of basaltic and granitic rock,[37] and specially designed trucks were used to reduce the number of trucks required, lower maintenance costs, and speed up the movement of crushed and broken stone during mining and processing operations.[38]

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Table 2.—Stone shipped or used by producers in the United States, by State

(Thousand short tons and thousand dollars)

State	1972 Quantity	1972 Value	1973 Quantity	1973 Value
Alabama [1]	18,485	42,027	20,043	40,117
Alaska	652	3,012	5,967	12,741
Arizona	4,638	8,018	4,265	9,469
Arkansas	16,317	25,020	16,223	26,209
California	37,213	65,811	43,838	77,175
Colorado	4,507	9,599	6,357	14,003
Connecticut	8,719	19,695	9,682	21,305
Florida [1]	52,732	79,877	61,735	103,595
Georgia	37,074	82,484	40,841	97,506
Hawaii	[1] 5,005	[1] 13,494	7,180	18,466
Idaho	3,094	7,042	2,972	8,096
Illinois	[1] 56,260	[1] 94,225	66,653	114,068
Indiana	27,511	50,919	[1] 32,288	[1] 57,652
Iowa	27,457	48,642	31,541	56,918
Kansas [1]	14,547	23,849	18,334	33,601
Kentucky [1]	34,279	59,690	38,205	70,912
Louisiana [1]	9,190	14,836	10,802	21,309
Maine	1,078	2,996	1,212	3,329
Maryland	19,431	41,973	18,585	46,732
Massachusetts	7,990	23,500	8,580	28,738
Michigan	39,754	50,317	45,886	60,494
Minnesota	5,757	16,318	7,581	20,411
Mississippi	1,135	1,199	[1] 760	[1] 809
Missouri	42,473	[1] 63,219	49,304	79,921
Montana	4,074	5,627	5,054	9,559
Nebraska	4,251	7,645	5,368	10,958
Nevada	3,329	5,926	3,595	5,429
New Hampshire	528	3,743	1,836	5,416
New Jersey [1]	r 15,223	r 42,044	15,902	45,585
New Mexico	2,768	5,499	2,830	5,894
New York	38,138	77,825	44,393	94,693
North Carolina	32,297	62,741	38,782	80,065
North Dakota	W	W	W	W
Ohio	48,498	90,821	[1] 55,107	[1] 98,009
Oklahoma	19,448	26,574	22,316	34,999
Oregon	10,915	18,380	13,411	21,843
Pennsylvania	67,307	124,340	78,564	150,346
Rhode Island	[1] 329	[1] 23	W	W
South Carolina	12,482	21,819	14,985	24,280
South Dakota	2,665	10,864	2,745	11,607
Tennessee	35,942	55,512	42,742	71,116
Texas	49,314	[1] 66,573	62,574	91,379
Utah	3,384	6,005	2,848	6,318
Vermont	3,300	26,170	1,871	19,523
Virginia	39,987	74,090	43,895	82,719
Washington	14,712	[1] 23,764	11,384	19,284
West Virginia [1]	11,649	21,293	11,732	22,821
Wisconsin	19,394	29,681	23,818	36,917
Wyoming	3,549	5,768	3,191	6,716
Undistributed [1]	1,639	11,801	2,345	11,412
Total [2]	r 920,423	r 1,672,293	1,060,124	1,990,463
Pacific Island Possessions	880	2,397	1,309	3,292
Puerto Rico	13,504	32,792	15,647	41,857
Virgin Islands	726	2,255	664	2,860

r Revised. W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] To avoid disclosing individual company data certain State totals are incomplete, the portion not included has been combined with "Undistributed." The class of stone omitted from such State totals is noted in the summary chapter of this volume.

[2] Data may not add to totals shown because of independent rounding.

Table 3.—Stone shipped or used by producers in the United States, by kind

(Thousand short tons and thousand dollars)

Year	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
	Granite		Traprock [1]		Marble		Limestone and dolomite		Shell	
1969	75,880	160,960	78,914	143,230	2,342	34,689	628,937	937,179	19,731	27,933
1970	86,709	183,312	77,227	146,661	1,785	33,734	625,796	961,013	21,713	31,035
1971	93,486	194,715	75,318	160,582	1,717	34,860	628,503	1,031,211	18,537	30,088
1972	106,887	225,571	r 77,044	r 159,934	2,318	41,545	671,907	1,105,085	16,610	29,571
1973	121,320	262,834	83,962	177,703	2,071	33,532	774,767	1,333,855	19,896	37,650
	Calcareous marl		Sandstone, quartz, and quartzite		Slate		Other stone [2]		Total [3]	
1969	2,490	2,516	27,456	64,272	1,308	13,831	25,831	39,983	862,889	1,424,594
1970	1,739	1,554	24,059	59,185	1,241	13,367	28,925	39,738	869,193	1,469,598
1971	3,459	4,504	30,729	84,630	1,232	13,615	23,143	39,860	876,123	1,594,065
1972	2,650	3,598	27,047	65,678	1,595	14,925	14,364	26,386	r 920,423	r 1,672,293
1973	2,327	3,042	30,647	78,084	1,555	15,980	23,580	47,785	1,060,124	1,990,463

r Revised.
[1] Includes gabbro, basalt, diabase, etc.
[2] Includes mica schist, conglomerate, argillite, various light-colored volcanic rocks, serpentine not used as marble, soapstone sold as dimension stone, etc.
[3] Data may not add to totals shown because of independent rounding.

Table 4.—Dimension stone shipped or used by producers in the United States by use and kind of stone

(Thousands)

Kind of stone and use	1972 Short tons	1972 Cubic feet	1972 Value	1973 Short tons	1973 Cubic feet	1973 Value
GRANITE						
Rough:						
Architectural	46	513	$2,139	49	533	$2,030
Construction [1]	54	652	662	113	1,236	912
Monumental	287	2,889	11,266	312	3,227	12,260
Flagging [2]	(3)	5	9	1	12	54
Dressed:						
Cut	W	W	W	36	432	11,323
Sawed	14	156	W	25	293	1,490
House stone veneer	6	71	132	5	63	153
Construction	10	111	636	4	54	371
Monumental	33	402	10,125	30	360	9,525
Curbing	130	1,537	6,217	136	1,610	7,688
Other dressed stone [4]	42	505	11,455	1	15	154
Total [5]	621	6,842	42,641	713	7,834	45,960
LIMESTONE AND DOLOMITE						
Rough:						
Architectural	175	2,400	4,070	139	1,872	3,040
Construction [1]	56	706	846	66	827	931
Flagging	18	220	246	14	179	248
Other rough stone [6]	1	18	21	2	20	14
Dressed:						
Cut	49	646	5,465	44	598	4,156
Sawed	30	402	1,377	32	433	1,369
House stone veneer	68	894	2,046	60	778	1,858
Construction	12	145	219	11	136	259
Flagging	2	25	50	2	23	43
Other dressed stone [6]	1	12	38	(3)	(3)	5
Total [5]	411	5,469	14,378	370	4,866	11,923
MARBLE						
Rough:						
Architectural	9	102	434	5	56	344
Construction [1]	W	W	W	9	106	214
Other rough stone [7]	W	W	W	(3)	2	2
Dressed:						
Cut	21	249	7,908	13	152	3,653
Sawed	5	62	932	3	33	484
House stone veneer	9	104	992	2	29	698
Construction }	[8] 27	316	6,275	W	W	W
Monumental }				15	175	4,633
Other dressed stone [9]	--	--	--	(3)	5	110
Total [5]	71	833	16,541	48	557	10,137
SANDSTONE, QUARTZ, AND QUARTZITE						
Rough:						
Architectural	42	553	614	48	637	959
Construction [1]	74	973	872	129	1,675	1,499
Flagging	18	218	894	22	273	1,167
Uses not specified	1	10	11	3	33	43
Dressed:						
Cut	21	273	1,139	20	261	1,003
Curbing	(3)	5	23	W	W	W
House stone veneer	27	342	907	25	338	767
Flagging	17	207	472	15	185	590
Other dressed stone [10]	32	429	2,752	35	478	2,408
Total [5]	231	3,011	7,684	296	3,879	8,437
SLATE						
Roofing slate [11]	12	--	1,369	12	--	1,478
Millstock:						
Structural and sanitary purposes	14	--	2,499	20	--	2,950
Blackboards, etc.[12]	1	--	173	3	--	662
Billiard tablet tops	4	--	641	W	--	W
Total	19	--	3,313	23	--	3,612
Flagging	36	--	1,146	35	--	1,217
Flooring	--	--	--	4	--	489
Other uses not listed [13]	14	--	1,576	14	--	1,160
Total [5]	80	--	7,404	88	--	7,956

See footnotes at end of table.

Table 4.—Dimension stone shipped or used by producers in the United States by use and kind of stone—Continued

(Thousands)

Kind of stone and use	1972 Short tons	1972 Cubic feet	1972 Value	1973 Short tons	1973 Cubic feet	1973 Value
OTHER STONE [14]						
Rough:						
Architectural	14	166	$142	10	123	$115
Construction [1]	43	509	645	39	471	583
Flagging	(3)	3	4	(3)	3	9
Dressed:						
Cut [15]	2	20	219	5	66	565
Construction	4	53	70	4	59	70
Other dressed stone [16]	--	--	--	5	54	213
Total [17]	66	783	1,964	[5] 64	776	1,555
TOTAL STONE						
Rough:						
Architectural	286	3,735	7,411	252	3,221	6,498
Construction [1]	239	2,991	3,172	358	4,317	4,149
Monumental	287	2,891	11,273	312	3,229	12,266
Flagging	36	447	1,169	38	471	1,490
Other rough stone [18]	2	30	29	4	52	52
Dressed:						
Cut	117	1,476	20,442	118	1,509	20,701
Sawed	65	845	4,814	80	1,040	4,531
House stone veneer	110	1,424	4,106	93	1,217	3,523
Construction	32	381	1,706	21	265	773
Roofing (slate) [11]	12	--	1,369	12	--	1,469
Millstock (slate)	19	--	3,313	23	--	3,612
Flooring (slate)	--	--	--	4	--	489
Monumental	65	778	19,511	45	534	14,157
Curbing	130	1,543	6,241	139	1,640	7,772
Flagging	61	300	1,806	54	227	1,891
Other dressed stone [19]	31	220	4,402	29	198	2,627
Total [5]	1,490	17,061	90,763	1,582	17,920	85,999

r Revised. W Withheld to avoid disclosing individual company confidential data.
1 Includes irregular shaped stone and rubble.
2 Includes unspecified rough stone for 1972.
3 Less than ½ unit.
4 Includes data for dressed flagging, paving blocks and figure where symbol W appears for granite.
5 Data may not add to totals shown because of independent rounding.
6 Data include small amount of monumental stone (1972), and uses not specified.
7 Includes data for monumental and flagging (1973).
8 Data combined to avoid disclosing individual company confidential data; also include flagging, uses not specified, and figure where symbol W appears for marble.
9 Data include construction stone, flagging and uses not specified.
10 Data include stone used for construction, sawed, uses not specified, and figure where symbol W appears for sandstone, quartz, and quartzite. 1972 data also include monumental stone, and stone used for structural and sanitary purposes.
11 Includes small amount of slate used for house stone veneer.
12 Includes slate used for electrical purposes and where symbol W appears for slate.
13 Includes slate used for aquarium bottoms, building stone, fireplaces, flooring (1972), and uses not specified (1973).
14 Produced by the following States in 1973, in order of value of output and with number of quarries: Hawaii (4), Maryland (4), New Mexico (3), Pennsylvania (3), Virginia (7), California (6), New Jersey (1), Oregon (6), and Washington (3).
15 1972 data include sawed stone and house stone veneer.
16 Data include sawed stone, house stone veneer, flagging and stone used for structural and sanitary purposes.
17 To avoid disclosing confidential data, 1972 figures include stone used for flagging, and structural and sanitary purposes.
18 Includes small amount of uses not specified.
19 Data include stone for paving blocks, structural and sanitary purposes (excluding slate), and uses not specified; slate for aquarium bottoms, building stone, fireplaces, and flooring (1972).

Table 5.—Granite (dimension stone) shipped or used by producers in the United States in 1973, by State

State	Active quarries	Quantity (short tons)	Value (thousands)
California	9	7,764	$591
Georgia	36	244,468	6,884
Massachusetts	8	73,777	5,674
Missouri	1	1,860	W
Montana	1	10	(1)
Nevada	1	W	10
New Hampshire	3	47,342	W
New York	3	11,952	W
North Carolina	11	39,309	2,391
Oklahoma	4	4,203	443
South Carolina	5	12,344	517
South Dakota	7	40,438	7,474
Virginia	1	673	14
Washington	1	76	2
Wisconsin	7	8,041	2,231
Other States [2]	44	221,070	19,728
Total [3]	142	713,327	45,960

W Withheld to avoid disclosing individual company confidential data; included with "Other States."

[1] Less than ½ unit.

[2] Includes quarries in Colorado (2), Connecticut (3), Maine (5), Maryland (1), Minnesota (17), Oregon (3), Texas (5), and Vermont (8).

[3] Data may not add to totals shown because of independent rounding.

Table 6.—Limestone and dolomite (dimension stone) shipped or used by producers in the United States in 1973, by State

State	Active quarries [1]	Quantity (short tons)	Value (thousands)
Florida	1	676	$59
Illinois	1	3,130	61
Indiana	23	216,810	6,828
Iowa	4	13,470	348
Minnesota	5	14,529	1,228
Nebraska	1	420	5
Oklahoma	3	1,496	24
Oregon	1	85	4
Virginia	3	1,744	W
Washington	1	1,281	38
Wisconsin	25	62,871	1,347
Other States [2]	22	53,350	1,980
Total [3]	90	369,862	11,923
Puerto Rico	3	162,213	859

W Withheld to avoid disclosing individual company confidential data; included with "Other States."

[1] Count may be duplicated for quarries that produce more than one kind of stone.

[2] Includes quarries in Alabama (1), California (5), Colorado (1), Kansas (5), Michigan (3), Missouri (1), Ohio (2), Rhode Island (1), and Texas (3).

[3] Data may not add to totals shown because of independent rounding.

Table 7.—Sandstone, quartz, and quartzite (dimension stone) shipped or used by producers in the United States in 1973

State	Active quarries [1]	Quantity (short tons)	Value (thousands)
Arizona	21	5,994	$128
Arkansas	3	7,115	192
California	4	950	24
Colorado	17	9,048	191
Maryland	4	13,399	313
Missouri	1	820	35
Montana	2	W	8
Nevada	1	1,040	50
New York	9	28,800	W
Ohio	24	105,922	2,996
Pennsylvania	19	61,478	964
Tennessee	4	10,228	439
Wisconsin	8	1,415	30
Wyoming	1	6	(2)
Other States [3]	28	50,121	3,067
Total	146	296,336	8,437

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Count may be duplicated for quarries that produce more than one kind of stone.
[2] Less than ½ unit.
[3] Includes quarries in Alabama (2), Connecticut (3), Georgia (3), Idaho (1), Indiana (2), Michigan (3), Minnesota (1), New Mexico (1), North Carolina (2), Utah (4), Virginia (3), Washington (2), and West Virginia (1).

Table 8.—Crushed and broken stone shipped or used by producers in the United States in 1972 and 1973, by kind of stone and use

(Thousand short tons and thousand dollars)

Kind of stone and use	1972 Quantity	1972 Value	1973 Quantity	1973 Value
CALCAREOUS MARL [1]				
Agricultural purposes [2]	133	166	249	376
Cement manufacture	[3] 2,517	[3] 3,431	2,025	2,585
Other uses [4]	--	--	53	82
Total [5]	2,650	3,598	2,327	3,042
GRANITE				
Bituminous aggregate	16,088	29,880	17,468	34,434
Concrete aggregate (coarse)	r 18,816	r 31,648	23,670	44,305
Dense-graded roadbase stone	37,877	66,219	40,099	70,367
Macadam aggregate	3,966	6,499	2,724	5,112
Surface treatment aggregate	5,696	9,837	6,763	12,734
Unspecified construction aggregate and roadstone	10,048	17,024	14,805	24,871
Riprap and jetty stone	4,036	7,543	2,996	5,992
Railroad ballast	6,162	9,169	6,271	10,056
Poultry grit and mineral food	W	W	35	W
Filter stone	W	W	413	990
Fill	97	88	W	W
Other uses [6]	r 3,481	r 5,022	5,361	8,012
Total [5]	106,266	182,930	120,606	216,874
LIMESTONE AND DOLOMITE				
Agricultural purposes [7]	27,140	58,436	37,759	76,140
Bituminous aggregate	49,977	90,520	63,237	118,180
Concrete aggregate (coarse)	100,173	167,746	113,244	201,979
Dense-graded roadbase stone	139,257	210,832	176,575	277,460
Macadam aggregate	26,993	43,753	30,221	51,617
Surface treatment aggregate	38,704	65,799	42,485	76,368
Unspecified construction aggregate and roadstone	71,647	117,731	81,875	134,595
Riprap and jetty stone	12,935	19,725	16,602	28,221
Railroad ballast	7,250	10,913	7,552	11,985
Filter stone	339	731	633	1,147
Manufactured fine aggregate (stone sand)	4,752	8,662	5,301	11,614
Terrazzo and exposed aggregate	124	1,433	328	4,280
Cement manufacture	101,304	118,199	106,878	137,202
Lime manufacture	28,858	46,818	33,135	53,770
Dead-burned dolomite	1,670	3,029	3,402	5,775
Ferrosilicon	1,030	W	439	522
Flux stone	24,728	40,422	27,664	48,409
Refractory stone	395	1,045	442	1,208

See footnotes at end of table.

Table 8.—Crushed and broken stone shipped or used by producers in the United States in 1972 and 1973, by kind of stone and use—Continued

(Thousand short tons and thousand dollars)

Kind of stone and use	1972 Quantity	1972 Value	1973 Quantity	1973 Value
LIMESTONE AND DOLOMITE—Continued				
Chemical stone for alkali works	4,199	9,205	2,943	6,529
Special uses and products [8]	876	3,386	984	3,482
Asphalt filler	954	4,525	795	3,951
Whiting or whiting substitute	662	9,252	683	11,653
Other fillers or extenders	1,368	8,338	2,051	14,078
Chemicals	635	1,683	1,181	2,636
Fill	4,243	4,841	1,630	2,328
Glass	1,794	6,827	1,724	7,268
Sugar refining	560	2,310	639	2,792
Other uses [9]	18,930	34,544	13,996	26,744
Total [5]	671,496	1,090,707	774,397	1,321,932
MARBLE				
Agricultural purposes [7]	44	239	14	W
Macadam aggregate	83	W	28	W
Concrete aggregate (coarse)				
Dense-graded roadbase stone				
Surface treatment aggregate				
Unspecified construction aggregate and roadstone	[10] 862	3,826	637	3,745
Riprap and jetty stone				
Filter stone				
Manufactured fine aggregate (stone sand)				
Terrazzo and exposed aggregate	203	3,086	149	2,282
Mineral fillers, extenders, whiting	[11] 1,047	[11] 17,854	1,038	16,631
Other uses	8	W	[12] 157	[12] 738
Total [5]	2,247	25,005	2,023	23,395
SANDSTONE, QUARTZ, AND QUARTZITE [13]				
Bituminous aggregate	1,613	3,547	2,645	5,942
Concrete aggregate (coarse)	2,092	4,061	2,258	5,131
Dense-graded roadbase stone	8,744	14,216	7,370	12,273
Macadam aggregate	351	571	98	157
Surface treatment aggregate	951	1,842	1,003	1,939
Unspecified construction aggregate and roadstone	3,290	5,975	6,758	12,143
Riprap and jetty stone	2,213	4,550	2,855	6,075
Railroad ballast	1,014	1,536	914	1,635
Filter stone	52	84	168	379
Manufactured fine aggregate (stone sand)	343	930	567	1,603
Terrazzo and exposed aggregate	23	347	35	573
Cement and lime manufacture	522	1,288	776	1,700
Ferrosilicon	227	876	192	801
Flux stone	1,102	4,149	1,166	4,840
Refractory stone	211	1,746	416	3,043
Abrasives	45	W	226	1,253
Glass	925	3,315	1,034	4,435
Other uses [14]	3,100	8,960	1,869	5,724
Total [5]	26,817	57,994	30,351	69,647
SHELL				
Agricultural purposes [7]	W	W	425	1,725
Concrete aggregate (coarse)	W	W	W	W
Dense-graded roadbase stone	1,675	2,093	4,314	8,707
Unspecified construction aggregate and roadstone [15]	3,281	8,135	3,964	10,931
Cement and lime manufacture	5,675	9,301	6,687	11,163
Other uses [16]	5,980	10,042	4,506	5,124
Total [5]	16,610	29,571	19,896	37,650
TRAPROCK				
Bituminous aggregate	r 11,203	r 24,768	14,070	32,406
Concrete aggregate (coarse)	r 6,849	r 17,204	8,311	21,190
Dense-graded roadbase stone	r 18,566	r 35,817	22,058	44,857
Macadam aggregate	1,438	3,048	1,426	2,917
Surface treatment aggregate	5,341	9,430	4,737	9,322
Unspecified construction aggregate and roadstone	r 21,805	r 46,565	20,332	40,903
Riprap and jetty stone	r 3,501	r 6,249	4,131	8,094
Railroad ballast	2,332	3,753	2,878	4,885
Filter stone	117	287	112	253
Manufactured fine aggregate (stone sand)	231	811	604	1,728
Fill	1,686	1,018	1,799	2,591
Other uses [17]	3,966	r 10,833	3,502	8,527
Total [5]	r 77,034	r 159,783	83,959	177,671
OTHER STONE				
Bituminous aggregate	2,202	3,685	4,459	8,790
Concrete aggregate (coarse)	1,159	2,323	1,373	2,938
Dense-graded roadbase stone	3,051	5,153	7,227	15,492
Macadam aggregate	278	W	62	132

See footnotes at end of table.

Table 8.—Crushed and broken stone shipped or used by producers in the United States in 1972 and 1973, by kind of stone and use—Continued

(Thousand short tons and thousand dollars)

Kind of stone and use	1972		1973	
	Quantity	Value	Quantity	Value
OTHER STONE—Continued				
Surface treatment aggregate	591	807	1,330	1,721
Unspecified construction aggregate and roadstone	2,911	5,675	3,372	6,884
Riprap and jetty stone	1,738	2,650	1,285	2,099
Railroad ballast	W	1,072	654	506
Terrazzo and exposed aggregate	W	W	38	154
Fill	578	741	3,044	5,803
Other uses [18]	1,789	2,317	673	1,712
Total [5]	14,298	24,422	23,516	46,229
TOTAL STONE				
Agricultural purposes [7]	r 27,712	r 62,662	38,524	78,859
Bituminous aggregate	r 82,294	r 156,411	102,262	201,175
Concrete aggregate (coarse)	r 133,915	r 228,770	153,223	280,541
Dense-graded roadbase stone	r 209,218	r 334,455	257,778	429,453
Macadam aggregate	33,110	54,600	34,559	60,005
Surface treatment aggregate	51,943	89,128	56,993	104,001
Unspecified construction aggregate and roadstone	r 111,400	r 196,455	130,356	227,635
Riprap and jetty stone	r 24,438	r 40,792	27,932	50,806
Railroad ballast	18,021	26,443	18,281	29,123
Filter stone	636	1,353	1,327	2,770
Manufactured fine aggregate (stone sand)	r 5,976	r 12,929	7,748	19,182
Terrazzo and exposed aggregate	402	5,075	566	7,542
Cement manufacture	108,857	129,743	115,487	151,225
Lime manufacture	30,051	49,386	34,070	55,348
Dead-burned dolomite	1,670	3,029	3,402	5,775
Ferrosilicon	1,257	2,904	631	1,323
Flux stone	25,830	44,571	28,829	53,249
Refractory stone	605	2,792	858	4,251
Chemical stone for alkali works	4,199	9,205	2,943	6,529
Special uses and products [8]	r 965	r 4,278	1,257	5,385
Asphalt filler	1,136	5,075	977	4,404
Whiting or whiting substitute	1,139	15,728	1,076	16,654
Other fillers or extenders	2,148	19,783	2,902	26,459
Fill	6,630	6,713	7,262	11,519
Glass	2,718	10,142	2,759	11,703
Expanded slate	1,270	5,715	1,092	5,954
Roofing aggregates, chips, and granules	W	W	4,246	10,550
Other uses [19]	31,394	63,391	21,198	43,046
Total [5]	r 918,933	r 1,581,530	1,058,541	1,904,464

r Revised. W Withheld to avoid disclosing individual company confidential data.

[1] Produced by the following States in 1973, in order of tonnage: South Carolina, Mississippi, Texas, North Carolina, Michigan, Indiana, and Virginia.

[2] Includes marl used in agricultural limestone, agricultural marl and other soil conditioners and nutrients, and minor amounts of filler.

[3] Data include small amount of fill.

[4] Data include stone used in dense-graded roadbase stone, unspecified aggregate, and fill.

[5] Data may not add to totals shown because of independent rounding.

[6] Includes stone used in manufactured fine aggregate, terrazzo, cement manufacture, asphalt filler, drain fields (1972), fill (1973), roofing aggregate, chips, and granules, waste material, uses not specified, and any data represented by the symbol W in granite.

[7] Includes agricultural limestone, agricultural marl and other soil conditioners, and poultry grit and mineral food.

[8] Includes stone used for abrasives and mine dusting.

[9] Data include stone used in acid neutralization, building products, bedding material (1973) disinfectant and animal sanitation, drain fields, dam construction (1972), magnesium metal manufacture, paper manufacture, roofing aggregates, chips, and granules, stucco, waste material, use not specified, and any data represented by the symbol W in limestone and dolomite.

[10] Data combined to avoid disclosing confidential data. Includes surface treatment and filter stone (1972).

[11] Includes a minor amount of stone used in roofing aggregates, chips, and granules and any data represented by the symbol W in marble.

[12] Includes bituminous aggregate, roofing aggregates, chips, and granules (1973), and any data represented by the symbol W in marble.

[13] Includes ground sandstone, quartz, and quartzite.

[14] Includes stone used in poultry grit and mineral food, building products, drain fields (1973), fill, other filler (1973), roofing aggregates, chips, and granules, waste material (1973), and uses not specified.

[15] Includes stone used for concrete aggregate (1973), bituminous aggregate, and surface treatment aggregate.

[16] Includes stone used for asphalt filler (1973), railroad ballast (1973), riprap and jetty stone (1973), uses not specified and any data represented by the symbol W in shell.

[17] Data include stone used for asphalt filler, bedding material (1973), drain fields, other fillers or extenders, roofing aggregates, chips, and granules, terrazzo (1972), waste material (1973), and uses not specified.

[18] Includes stone used for asphalt and other fillers, cement manufacture, roofing aggregates, chips, and granules, manufactured fine aggregate, abrasives, drain fields, waste material, uses not specified, and data represented by the symbol W in other stone.

[19] Data include stone used in building products, flour (slate), uses not listed in smaller quantities, and uses not specified.

Table 9.—Number and production of crushed-stone quarries in the United States, by size of operation

Annual production (short tons)	1972 Number of Quarries	1972 Production Thousand short tons	1972 Production Percent of total	1973 Number of Quarries	1973 Production Thousand short tons	1973 Production Percent of total
Less than 25,000	1,756	14,885	1.6	1,600	13,603	1.3
25,000 to 49,999	521	18,809	2.0	660	24,221	2.3
50,000 to 74,999	350	21,400	2.3	339	20,485	1.9
75,000 to 99,999	245	21,316	2.3	253	21,941	2.1
100,000 to 199,999	536	76,667	8.3	634	90,974	8.6
200,000 to 299,999	336	82,870	9.0	308	75,868	7.2
300,000 to 399,999	225	78,252	8.5	233	80,946	7.6
400,000 to 499,999	160	71,911	7.8	182	80,956	7.6
500,000 to 599,999	105	57,761	6.3	126	68,903	6.5
600,000 to 699,999	84	54,051	5.9	98	62,730	5.9
700,000 to 799,999	55	41,030	4.5	76	56,694	5.4
800,000 to 899,999	43	36,578	4.0	51	42,718	4.0
900,000 to and over	211	r 343,401	37.4	248	418,502	39.5
Total [1]	4,627	r 918,933	100.0	4,808	1,058,541	100.0

r Revised.
[1] Data may not add to totals shown because of independent rounding.

Table 10.—Crushed stone shipped or used in the United States by method of transportation

Method of transportation	1972 Thousand short tons	1972 Percent of total	1973 Thousand short tons	1973 Percent of total
Truck	r 689,782	75	830,372	78
Rail	r 101,585	11	98,771	9
Waterway	63,156	7	77,741	7
Other	26,620	3	31,746	3
Unspecified	37,791	4	19,911	2
Total [1]	r 918,933	100	1,058,541	100

r Revised.
[1] Data may not add to totals shown because of independent rounding.

Table 11.—Granite (crushed and broken stone) shipped or used by producers in the United States in 1973, by State

(Thousand short tons and thousand dollars)

State	Quantity	Value	State	Quantity	Value
Alaska	225	951	Oregon	112	W
Arizona	43	77	South Carolina	11,096	17,738
California	6,108	10,119	Texas	25	236
Colorado	1,672	2,767	Utah	(1)	(1)
Georgia	32,896	61,925	Virginia	16,185	30,156
Idaho	328	560	Washington	748	970
Maine	104	302	Wisconsin	1,920	783
Minnesota	920	1,671	Other States [2]	14,201	22,542
Montana	62	175	Total [3]	120,606	216,874
New Jersey	2,715	5,663			
North Carolina	31,246	60,241			

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Less than ½ unit.
[2] Includes Arkansas, Connecticut, Maryland, Massachusetts, Michigan, Missouri, Nevada, New Hampshire, Pennsylvania, Rhode Island, Vermont, and Wyoming.
[3] Data may not add to totals shown because of independent rounding.

Table 12.—Traprock (crushed and broken stone) shipped or used by producers in the United States in 1973, by State

(Thousand short tons and thousand dollars)

State	Quantity	Value	State	Quantity	Value
California	5,359	9,423	Oregon	12,315	19,795
Colorado	(1)	(1)	Pennsylvania	6,122	9,788
Connecticut	8,999	18,065	Virginia	4,872	10,460
Hawaii	4,966	13,656	Washington	8,715	14,181
Idaho	1,660	3,351	Wyoming	355	1,176
Massachusetts	5,435	12,974	Other States [2]	12,067	28,844
Michigan	21	34	Total [3]	83,959	177,671
Minnesota	153	358	Puerto Rico	W	W
Montana	730	879	Virgin Islands	664	2,860
New Jersey	12,191	34,688			

W Withheld to avoid disclosing individual company confidential data.
[1] Less than ½ unit.
[2] Includes Alaska, Arizona, Maine, Maryland, Missouri, New Hampshire, New Mexico, New York, North Carolina, Oklahoma, Texas, Vermont, and Wisconsin.
[3] Data may not add to totals shown because of independent rounding.

Table 13.—Limestone and dolomite (crushed and broken) shipped or used by producers in the United States in 1973, by State and use

(Thousand short tons and thousand dollars)

State	Agriculture [1]		Aggregates		Riprap		Railroad ballast		Fluxing stone		Miscellaneous and undistributed		Total [2]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	728	1,317	10,404	14,966	W	W	W	W	656	1,264	6,178	9,938	17,966	27,485
Alaska	--	--	W	W	--	--	--	--	--	--	W	W	W	W
Arizona	--	--	229	521	--	--	--	--	364	1,016	1,717	2,508	2,310	4,045
Arkansas	390	936	2,417	4,507	W	18	--	--	W	W	2,873	3,930	5,679	9,392
California	149	805	4,435	7,262	158	240	--	--	W	W	17,054	29,143	21,796	37,450
Colorado	W	W	W	W	W	W	W	W	W	W	4,200	9,750	4,200	9,750
Connecticut	W	W	--	--	W	W	--	--	--	--	224	1,378	224	1,378
Florida	1,425	4,326	53,342	87,621	W	W	295	566	--	--	6,672	11,024	61,734	103,537
Georgia	381	942	3,858	7,576	W	W	W	W	--	--	2,420	6,821	6,659	15,340
Hawaii	26	W	493	1,237	--	--	--	--	--	--	1,226	2,701	1,746	3,937
Idaho	6	W	--	--	--	--	--	--	--	--	W	W	W	450
Illinois	4,533	7,732	52,728	90,929	951	1,633	489	788	963	1,775	6,987	11,149	66,650	114,007
Indiana	1,842	3,265	25,557	41,570	259	602	402	601	W	W	3,970	4,736	32,030	50,774
Iowa	2,005	4,991	23,913	43,549	277	451	W	W	W	W	5,250	7,447	31,445	56,437
Kansas	540	805	13,006	25,521	W	472	W	W	--	--	4,111	5,456	17,658	32,254
Kentucky	1,868	3,652	28,828	52,295	2,332	5,218	415	797	W	W	4,763	8,950	38,205	70,912
Maine	W	W	W	W	--	--	--	--	--	--	W	W	W	W
Maryland	W	W	10,170	21,726	W	W	--	--	W	W	3,211	10,386	13,381	32,113
Massachusetts	170	W	W	W	--	--	--	--	8	50	W	W	W	W
Michigan	660	1,000	10,586	14,624	411	612	246	385	13,241	19,021	19,876	21,265	45,021	56,908
Minnesota	223	416	5,694	8,393	44	62	W	W	W	W	357	714	6,318	9,585
Mississippi	W	W	W	W	W	W	W	--	--	--	W	W	W	W
Missouri	4,507	8,095	27,381	47,664	3,772	3,870	62	113	W	W	13,028	16,872	48,750	76,613
Montana	--	--	W	33	2	2	--	--	W	W	1,398	2,465	1,400	2,500
Nebraska	186	1,271	3,095	6,511	747	1,674	--	--	--	--	1,339	1,497	5,368	10,953
Nevada	W	W	W	257	W	W	--	--	W	W	W	W	2,403	4,312
New Jersey	W	W	W	1,594	--	--	--	--	W	W	W	W	W	W
New Mexico	--	--	305	480	--	--	--	--	13	W	W	W	1,118	2,555
New York	348	1,671	27,357	59,711	895	2,013	199	396	W	W	11,369	16,353	40,168	80,144
North Carolina	W	W	W	W	W	W	--	--	--	--	W	W	W	W
Ohio	1,429	2,680	34,037	56,647	1,464	2,953	1,191	1,643	3,387	5,784	12,450	24,661	53,957	94,368
Oklahoma	W	W	10,280	17,615	370	507	W	W	--	--	10,592	14,888	21,242	33,010
Oregon	W	W	W	W	--	--	--	--	W	W	W	W	W	W
Pennsylvania	2,345	6,988	37,149	65,349	623	1,159	871	1,597	3,670	8,691	17,765	31,301	62,423	115,083
Rhode Island	W	W	--	--	--	--	--	--	W	W	W	W	W	W
South Carolina	298	670	W	W	294	535	2	1	--	--	W	W	W	W

South Dakota	--	--	821	1,221	8	10	W	W	--	--	W	W	1,661	1,843
Tennessee	2,852	4,554	34,227	53,776	949	1,427	W	W	--	--	4,444	8,285	42,473	68,041
Texas	339	672	39,511	53,118	768	1,189	590	891	584	1,357	11,941	15,588	53,733	72,816
Utah	W	W	W	W	14	13	--	--	W	W	2,035	4,719	2,049	4,731
Vermont	77	292	683	1,160	30	W	W	W	--	--	314	W	1,103	7,196
Virginia	1,165	2,357	13,535	21,047	66	90	296	428	363	626	4,559	7,840	19,984	32,389
Washington	14	67	61	89	1	5	--	--	W	W	903	1,530	980	1,692
West Virginia	83	170	7,131	13,513	45	98	504	627	1,075	2,469	2,259	4,361	11,096	21,237
Wisconsin	625	1,277	18,050	24,397	297	683	172	231	W	W	422	765	19,565	27,351
Wyoming	--	--	W	W	W	W	W	W	--	--	868	1,932	868	1,932
Total [2]	29,214	60,951	499,283	846,479	14,777	25,536	5,734	9,064	24,324	42,053	186,775	300,353	763,363	1,294,520
Undistributed	8,543	15,189	8,356	13,721	1,827	2,684	1,818	2,922	3,339	6,357	14,292	37,498	11,035	27,412
Pacific Island Possessions	W	W	1,158	3,021	16	20	--	--	--	--	136	250	1,309	3,292
Puerto Rico	--	--	8,497	18,644	W	W	--	--	--	--	3,134	3,509	11,631	22,153

W Withheld to aoid disclosing indiidual company confidential data; included with "Undistributed."
[1] Includes agricultural limestone, agricultural marl and other soil conditioners, and poultry grit and mineral food.
[2] Data may not add to totals shown because of independent rounding.

Table 14.—Shell shipped or used by producers in the United States in 1973, by State

(Thousand short tons and thousand dollars)

State	Quantity	Value
Louisiana	10,802	21,309
Mississippi	143	150
Texas	6,380	11,009
Virginia	1	W
Other States [1]	2,571	5,182
Total [2]	19,896	37,650

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes Alabama, California, Florida, and Maryland.
[2] Data may not add to totals shown because of independent rounding.

Table 15.—Calcareous marl shipped or used by producers in the United States in 1973 by State

(Thousand short tons and thousand dollars)

State	Quantity	Value
Indiana	41	49
Michigan	73	79
Mississippi	617	659
North Carolina	93	204
Other States [1]	1,503	2,051
Total	2,327	3,042

[1] Includes South Carolina, Texas, and Virginia.

Table 16.—Sandstone, quartz, and quartzite (crushed and broken stone) shipped or used by producers in the United States in 1973, by State

(Thousand short tons and thousand dollars)

State	Quantity	Value	State	Quantity	Value
Alabama	W	81	Oregon	230	483
Arizona	1,026	3,183	Pennsylvania	5,650	11,806
Arkansas	3,978	6,549	Texas	1,671	3,919
California	5,736	9,440	Utah	111	139
Colorado	409	1,029	Vermont	222	420
Georgia	107	W	Virginia	1,644	2,927
Idaho	575	3,190	Washington	417	1,323
Kansas	576	W	West Virginia	636	1,584
Maryland	76	552	Wyoming	31	18
Montana	204	533	Other States [1]	4,611	14,786
New York	1,198	3,821	Total [2]	30,351	69,647
North Carolina	93	223			
Ohio	1,149	3,641			

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes Connecticut, Indiana, Kentucky, Maine, Michigan, Missouri, Nevada, New Hampshire, Oklahoma, South Dakota, Tennessee, and Wisconsin.
[2] Data may not add to totals shown because of independent rounding.

Table 17.—Miscellaneous varieties of stone (crushed and broken) shipped or used by producers in the United States in 1973, by State

(Thousand short tons and thousand dollars)

State	Quantity	Value	State	Quantity	Value
Alaska	3,779	9,009	New Hampshire	100	100
Arkansas	W	234	New Mexico	967	1,624
California	4,668	9,591	Oklahoma	679	704
Colorado	65	143	Oregon	301	516
Hawaii	443	675	Pennsylvania	4,015	8,227
Idaho	71	119	Rhode Island	W	31
Iowa	82	133	Texas	484	572
Maryland	495	W	Vermont	99	115
Michigan	(1)	(1)	Other States [2]	4,567	9,011
Montana	2,656	5,330	Total [3]	23,516	46,229
Nevada	46	93	Puerto Rico	2,462	15,588

W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Less than ½ unit.
[2] Includes Arizona, Kansas, Louisiana, Maine, Massachusetts, Minnesota, Missouri, New York, North Carolina, North Dakota, South Dakota, Utah, Virginia, Washington, Wisconsin, and Wyoming.
[3] Data may not add to totals shown because of independent rounding.

Table 18.—U.S. exports of stone

(Thousand short tons and thousand dollars)

Year	Building and monumental stone			Crushed, ground, or broken				Other manufactures of stone (value)
	Dolomite		Other (value)	Limestone		Other		
	Quantity	Value		Quantity	Value	Quantity	Value	
1971	87	1,639	905	1,823	3,752	585	3,871	1,322
1972	77	1,025	755	1,730	3,802	1,035	4,298	1,227
1973	59	652	1,244	2,316	5,400	765	4,819	948

Table 19.—U.S. imports for consumption of stone and whiting, by class

Class	1972 Quantity	1972 Value (thousands)	1973 Quantity	1973 Value (thousands)
Granite:				
Monumental, pavings, and building stone:				
Rough ---- cubic feet	498,360	$1,576	344,739	$2,183
Dressed, manufactured ---- do	825,697	7,610	565,771	6,214
Not manufactured and not suitable for monumental, paving or building stone ---- short tons	1,141	25	3,595	51
Other, n.s.p.f	(1)	179	(1)	135
Total	XX	9,390	XX	8,583
Marble, breccia, and onyx:				
In block, rough or squared ---- cubic feet	25,412	295	19,124	213
Sawed or dressed, over 2 inches thick ---- do	5,347	76	3,780	104
Slabs and paving tiles ---- superficial feet	8,098,013	r 8,376	9,165,049	10,033
All other manufactures	(1)	7,280	(1)	8,102
Total	XX	r 16,027	XX	18,452
Travertine stone:				
Rough, unmanufactured ---- cubic feet	7,091	28	5,262	23
Dressed, suitable for monumental, paving and building stone ---- short tons	22,928	2,839	19,056	3,112
Other, n.s.p.f	(1)	110	(1)	155
Total	XX	2,977	XX	3,290
Limestone:				
Monumental, paving, and building stone:				
Rough ---- cubic feet	5,955	4	7,394	8
Dressed, manufactured ---- short tons	3,385	29	2,244	58
Crude, not suitable for monumental, paving or building stone ---- do	21,349	76	18,864	75
Other, n.s.p.f	(1)	24	(1)	47
Total	XX	133	XX	188
Slate:				
Roofing ---- square feet	750	(2)	--	--
Other, n.s.p.f	(1)	5,679	(1)	6,545
Total	XX	5,679	XX	6,545
Quartzite ---- short tons	63,886	557	98,137	973
Stone and articles of stone n.s.p.f.:				
Statuary and sculptures	(1)	354	(1)	358
Stone, manufacutured ---- short tons	29,978	486	22,830	1,613
Building stone, rough ---- cubic feet	4,220	4	3,969	9
Building stone, dressed ---- short tons	514	69	3,546	147
Other	(1)	2,291	(1)	2,358
Total	XX	3,204	XX	4,485
Stone, chips, spall, crushed or ground:				
Marble, breccia, and onyx chips ---- short tons	11,590	150	5,373	133
Limestone, chips and spalls, crushed or ground ---- do	1,850,205	2,567	1,734,479	2,466
Stone chips and spalls and stone crushed or ground n.s.p.f ---- do	1,335,240	1,976	1,538,342	2,356
Slate chips and spalls and slate crushed or ground ---- do	14	5	--	--
Total	3,197,049	4,698	3,278,194	4,955
Whiting:				
Whiting, dry, ground, or bolted ---- short tons	20,782	621	26,653	875
Chalk whiting, precipitated ---- do	1,895	150	3,332	332
Total	22,677	771	29,985	1,207
Grand total	XX	r 43,436	XX	48,678

r Revised. XX Not applicable.
1 Quantity not reported.
2 Less than ½ unit.

Sulfur and Pyrites

By Roland W. Merwin [1] and William F. Keyes [2]

Conditions in the sulfur industry improved over those of 1972. Production, shipments, and apparent domestic consumption reached alltime highs. The price position of elemental sulfur increased moderately over that of 1972, reversing the downward trend that had prevailed for several years. Most of the price increases were effective the latter part of 1973, with strong indications at yearend that there would be a substantial improvement in domestic prices in 1974. The improved conditions in the sulfur industry resulted from a continuing upsurge in sulfur demand for fertilizer manufacturing.

There was a substantial increase in the production of both Frasch and recovered sulfur over that of the previous year. However, the production of sulfur in other forms decreased moderately. Shipments of sulfur in all forms by domestic producers increased because of increases in domestic consumption. Production of sulfur in all forms exceeded shipments by a moderate amount, with the excess being placed in Frasch producers' stockpiles as a reserve against forward commitments for this product.

The total value of shipments of sulfur in all forms increased from $194.6 million in 1972 to $207.8 million in 1973. The average net shipment value, f.o.b. mine/plant, for Frasch and recovered elemental sulfur, which accounted for 92% of the total shipments of sulfur in all forms in 1973, increased from $17.03 per long ton in 1972 to $17.84 per long ton in 1973.

The United States maintained its position as a net exporter of sulfur in all forms in 1973. However, net exports were substantially less than those in the previous year as the result of a moderate decrease in exports and a moderate increase in imports as compared to those in 1972. The maintenance of the export-import balance reflected strenuous efforts on the part of domestic producers to maintain their competitive position in both domestic and world markets in the face of strong foreign competition and low price levels.

[1] Supervisory physical scientist, Division of Nonmetallic Minerals—Mineral Supply.
[2] Physical scientist, Division of Nonmetallic Minerals—Mineral Supply.

Table 1.—Salient sulfur statistics

(Thousand long tons, sulfur content)

	1969	1970	1971	1972	1973
United States:					
Production:					
Frasch	7,146	7,082	7,025	7,290	7,605
All forms	9,545	9,557	9,580	r 10,218	10,921
Exports, sulfur	1,551	1,433	1,536	1,852	1,777
Imports, pyrites and sulfur	1,795	1,667	1,429	1,188	1,222
Stocks Dec. 31: Producer, Frasch, and recovered sulfur	3,338	3,829	4,120	r 3,796	3,927
Consumption, apparent, all forms [1]	9,169	9,227	9,173	r 9,854	10,234
World production:					
Sulfur, elemental	20,785	22,162	r 24,792	r 28,209	31,555
Pyrites	9,432	10,190	r 11,112	r 10,301	9,960

r Revised.
[1] Measured by quantity sold, plus imports, minus exports.

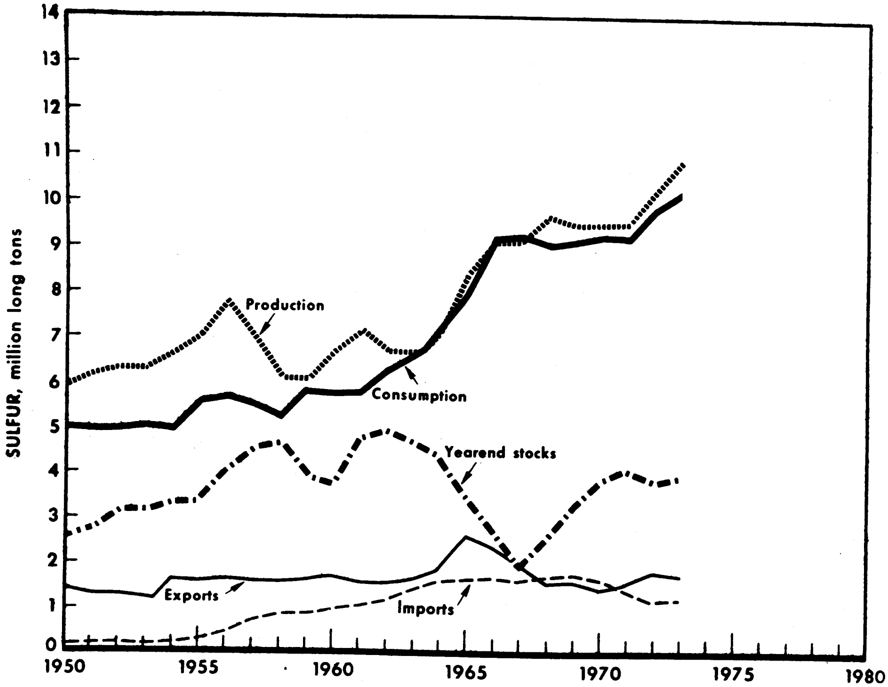

Figure 1.—Trends in the sulfur industry in the United States.

DOMESTIC PRODUCTION

Frasch Sulfur.—Frasch sulfur accounted for 70% of the domestic production of sulfur in all forms in 1973, compared with 71% in 1972. All of it was produced from Frasch mines in Texas and Louisiana.

In 1973, 12 Frasch mines produced sulfur. The producers and mines in Louisiana were Freeport Minerals Co. at Garden Island Bay, Grand Isle, Grande Ecaille, and Lake Pelto; and Texasgulf, Inc., at Bully Camp. The producers and mines in Texas were Atlantic Richfield Co. at Fort Stockton; Duval Corp. at Culberson; Jefferson Lake Sulphur Co. at Long Point Dome; and Texasgulf, Inc., at Boling Dome, Fannett Dome, Moss Bluff Dome, and Spindletop Dome.

Production of domestic Frasch sulfur increased in 1973, being 4% more than that of 1972 and 2% more than the previous alltime peak production in 1968. This was a reflection of a projected substantial increase in sulfur demand in the domestic fertilizer manufacturing market and an anticipated stable level of demand in foreign markets.

There was a continuing tendency to concentrate production in the larger low-cost mines to counteract the adverse effects of low sulfur prices and increasing production costs. During 1969, 9 producers operated 21 mines. By 1973 this was reduced to 5 producers operating 12 mines. The 12 mines remaining in operation increased their production over that of 1969 by 1,344,000 tons, or 21%. Seven of the mines showed increases in production rates over those during 1969, and the other five registered decreases.

In 1973 the five largest mines, with production rates in excess of one-half million tons per year each, accounted for 78% of the total Frasch sulfur output and 54% of the total production of sulfur in all forms during the year. Three medium-sized mines, with production rates of more than 250,000 tons per year each, contributed an additional 14% of the year's Frasch production. The remaining 8% of the Frasch output came from four smaller mines.

Ten mines, operated by Duval Corp., Freeport Minerals Co., and Texasgulf, Inc., accounted for most of the Frasch production. Only a relatively small portion of the output was obtained from the other two producers, operating one mine each.

Producers' shipments of Frasch sulfur decreased 2% from those in 1972, as a result of slight decreases in demand in both the domestic and export markets. Frasch production exceeded shipments by 167,000 tons, or 2%, with the excess production being placed in producers' stocks as a reserve against forward commitments. Approximately 76% of the shipments were for domestic consumption and 24% for export.

Despite a decline in the quantity shipped, the total value of the shipments, f.o.b. mine, increased by 5% over that of 1972. The average reported unit shipping value, f.o.b. mine, was $18.63 per ton in 1973, compared with $17.39 per ton in 1972. These increases reflected a substantial improvement in sulfur prices in the latter months of 1973.

Recovered Sulfur.—Recovered elemental sulfur accounted for 22% of the total domestic production of sulfur in all forms compared with 19% in 1972. This was a reflection of the rapidly increasing importance of recovered sulfur as a source of U.S. sulfur supply.

Production and shipments of this product in 1973 reached alltime highs with increases of 24% and 27%, respectively, over those in 1972. The total value of shipments increased by 26%. However, the average reported shipment value, f.o.b. plant, declined slightly from $15.60 per ton in 1972 to $15.45 per ton in 1973.

Recovered sulfur was produced at 132 plants in 28 States. Most of the plants were of relatively small size, with only three of them reporting an annual production exceeding 100,000 tons. The 10 largest plants accounted for 37% of the total output, and the combined production of the 5 leading States amounted to 73% of the total. By source, 57% was produced at refineries or at satellite plants treating refinery gases, and 43% was produced at natural gas treatment plants.

The five largest recovered sulfur producers were Exxon Company, U.S.A., Getty Oil Co., Shell Oil Company, Stand-

Table 2.—Production of sulfur and sulfur-containing raw materials by producers in the United States

(Thousand long tons)

	1970		1971		1972		1973	
	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
Frasch sulfur	7,082	7,082	7,025	7,025	7,290	7,290	7,605	7,605
Recovered elemental sulfur	1,457	1,457	1,595	1,595	r 1,950	r 1,950	2,416	2,416
Byproduct sulfuric acid (basis 100%) produced at Cu, Zn, and Pb plants	1,642	537	1,585	518	1,669	546	1,795	600
Pyrites	845	339	808	316	741	283	559	212
Other forms [1]	161	142	149	126	173	149	107	88
Total	--	9,557	--	9,580	--	r 10,218	--	10,921

r Revised.
[1] Hydrogen sulfide and liquid sulfur dioxide.

Table 3.—Sulfur produced and shipped from Frasch mines in the United States

(Thousand long tons and thousand dollars)

Year	Production			Shipments	
	Texas	Louisiana	Total [1]	Quantity	Value [2]
1969	3,289	3,857	7,146	6,540	173,937
1970	3,446	3,636	7,082	6,504	153,809
1971	3,408	3,616	7,025	6,738	117,894
1972	3,755	3,534	7,290	7,613	132,385
1973	4,294	3,311	7,605	7,438	138,578

[1] Data may not add to totals shown because of independent rounding.
[2] F.o.b. mine.

ard Oil Co. of California, and Standard Oil Co. (Indiana). Together, their 38 plants accounted for 51% of recovered sulfur production.

The production was nondiscretionary as a byproduct from natural gas and petroleum refinery operations. As such, it was produced and marketed regardless of demand or price and generally sold in close proximity to the points of production. As a result of local competitive factors in the regional markets served by recovered sulfur producers, including competition from Canadian sources in northern areas of the Nation, there were wide variations between the unit sales prices, f.o.b. plant, reported in the different regions of the Nation. This was in marked contrast to the more stable marketing of Frasch sulfur.

The States of Alabama, Florida, and Mississippi continued to emerge as major producers of recovered sulfur. This development was based on the rapidly expanding exploitation of dry sour natural gas and sour natural gas associated with petroleum in the deep Jurassic formations underlying these States. With existing plants increasing their production and with new plants under construction, there was every indication of a substantial increase in recovered sulfur production in this 3-State area within the next few years.

Petroleum refineries, particularly those along the coastal areas of the Nation, continued to install additional sulfur recovery capacity and modify process equipment for the refining of sour crudes in the expectation of increasing imports of this type of petroleum from the Near East. It was anticipated that these actions would sharply increase the production of recovered sulfur from these sources within the next few years.

Byproduct Sulfuric Acid.—The sulfur contained in byproduct sulfuric acid produced at copper, lead, and zinc roasters and smelters during 1973 amounted to 5% of the total domestic production of sulfur in all forms. It was produced at 18 plants in 12 States. Eight acid plants operated in conjunction with copper smelters, and 10 plants operated as accessories to lead and zinc roasting and smelting operations. The five largest acid plants accounted for 57% of the output, and the combined production of five States amounted to 79% of the

Table 4.—Recovered sulfur produced and shipped in the United States

(Thousand long tons and thousand dollars)

Year	Production	Shipments	
	Gross weight	Gross weight	Value [1]
1969	1,422	1,408	41,037
1970	1,457	1,471	30,725
1971	1,595	1,582	27,483
1972 [r]	1,950	1,927	30,060
1973	2,416	2,451	37,873

[r] Revised.
[1] F.o.b. plant.

Table 5.—Recovered sulfur shipped in the United States, by State

(Thousand long tons and thousand dollars)

State	1972		1973	
	Quantity	Value	Quantity	Value
Arkansas	25	365	24	343
California	320	5,131	433	4,539
Florida	[r] 92	W	225	3,529
Illinois and Indiana	134	2,510	168	3,562
Louisiana and Mississippi	[r] 74	[r] 1,415	243	3,866
Michigan and Minnesota	60	971	53	929
New Jersey	67	1,678	82	1,893
New Mexico	35	336	38	364
New York	4	W	4	W
Ohio	W	W	7	111
Oklahoma	1	9	1	8
Pennsylvania	22	532	25	461
Texas	[r] 852	[r] 11,174	847	12,018
Wyoming	40	W	49	W
Other States [1]	[r] 202	[r] 5,937	252	6,250
Total [2]	[r] 1,927	[r] 30,060	2,451	37,873

[r] Revised. W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Combined to avoid disclosing individual company confidential data; includes Alabama, Colorado, Delaware, Kansas, Missouri, Montana, North Dakota, Ohio (1972), Utah (1973), Virginia, Washington, and Wisconsin (1973).
[2] Data may not add to totals shown because of independent rounding.

total. The total output was 10% more than that in 1972, and the value of shipments was 6% more than that in 1972.

The five largest producers of byproduct sulfuric acid were American Smelting and Refining Co., The Bunker Hill Co., Kennecott Copper Corp., Phelps Dodge Corporation, and St. Joe Minerals Corp. Together, their 12 plants produced 79% of the output during 1973.

A number of additional byproduct sulfuric acid plants were either under construction in 1973 or in the planning stage. Coupled with increasing production from the existing plants, it was anticipated that this type of production would increase rapidly within the next few years.

Pyrites, Hydrogen Sulfide, and Sulfur Dioxide.—The contained sulfur in these products amounted to 3% of the total domestic production of sulfur in all forms during 1973. Pyrites was produced at three mines in three States, hydrogen sulfide at seven plants in four States, and sulfur dioxide at one plant. Output was 31% less

Table 6.—Byproduct sulfuric acid [1] (sulfur content) produced in the United States

(Thousand long tons and thousand dollars)

Year	Copper plants [2]	Lead and zinc plants [3]	Total	Value
1969	200	317	517	27,508
1970	218	318	[4] 537	23,744
1971	234	284	518	21,293
1972	295	251	546	22,897
1973	318	282	600	24,175

[1] Includes acid from foreign materials.
[2] Excludes acid made from pyrites concentrates in Arizona, Montana, Tennessee, and Utah.
[3] Excludes acid made from native sulfur.
[4] Data does not add to total shown because of independent rounding.

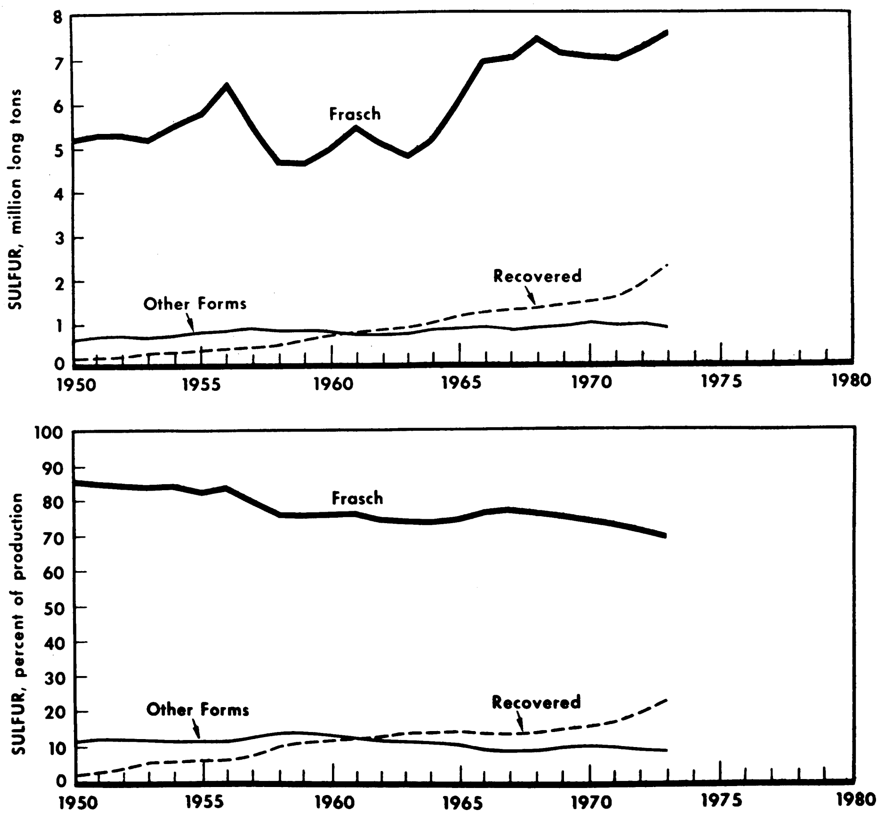

Figure 2.—Trends in the production of sulfur in the United States.

than in 1972. The value of these combined products was 22% less than that in 1972.

The four largest producers of these products were Phillips Petroleum Co. (hydrogen sulfide), Shell Oil Company (hydrogen sulfide), Standard Oil Co. of California (hydrogen sulfide), and Cities Service Co. (pyrites, hydrogen sulfide, and sulfur dioxide). Together, the one mine and seven plants accounted for 97% of the contained sulfur produced in the form of these products.

There was a marked reduction in the production of hydrogen sulfide below that of 1972 as producers found it to be technically and economically more advantageous to directly convert their product to recovered sulfur than to use it as a feedstock to a sulfuric acid plant.

Table 7.—Pyrites, hydrogen sulfide, and sulfur dioxide sold or used in the United States

(Thousand long tons of sulfur content and thousand dollars)

Year	Pyrites	Hydrogen sulfide and sulfur dioxide	Total	Value
1970	339	142	481	12,214
1971	316	126	442	9,530
1972	283	149	432	9,227
1973	212	88	300	7,188

CONSUMPTION

Apparent consumption of sulfur in all forms reached an alltime high in 1973, being 4% more than that of 1972. This high level of consumption reflected an improvement in demand by the domestic fertilizer industry. With many new phosphoric acid plants either under construction or in the planning stages, there were indications that this condition would continue to improve during the next several years.

Sulfur for domestic consumption was obtained mainly from domestic sources: Frasch 55%, as compared to 58% in 1972; recovered 24%, as compared to 20% in 1972; and combined byproduct sulfuric acid, pyrites, hydrogen sulfide, and sulfur dioxide 9%, as compared to 10% in the previous year. The remaining 12% of the sulfur was obtained by imports of Frasch and recovered sulfur, with the percentage of supply being the same as in 1972. The decrease in the domestic Frasch industry's share of the domestic market and the increase by the domestic recovered sulfur industry continued a long-range trend.

The apparent sales of domestic Frasch sulfur to domestic consumers decreased by 100,000 tons, or 2% below those in 1972. Domestic producers of recovered sulfur increased their apparent sales to domestic consumers by 524,000 tons, or 27% over

Table 8.—Apparent consumption of sulfur in the United States [1]

(Thousand long tons)

	1969	1970	1971	1972	1973
Frasch:					
Shipments	6,540	6,504	6,738	7,613	7,438
Imports	745	539	449	269	302
Exports	1,551	1,433	1,536	1,852	1,777
Total	5,734	5,610	5,651	6,030	5,963
Recovered:					
Shipments	1,408	1,471	1,582	r 1,927	2,451
Imports	930	998	850	869	920
Total	2,338	2,469	2,432	r 2,796	3,371
Pyrites:					
Shipments	334	339	316	283	212
Imports e	120	130	130	50	--
Total	454	469	446	333	212
Smelter acid	517	537	518	546	600
Other forms [2]	126	142	126	149	88
Total all forms	9,169	9,227	9,173	r 9,854	10,234

e Estimate. r Revised.
[1] Crude sulfur or sulfur content.
[2] Includes consumption of hydrogen sulfide and liquid sulfur dioxide.

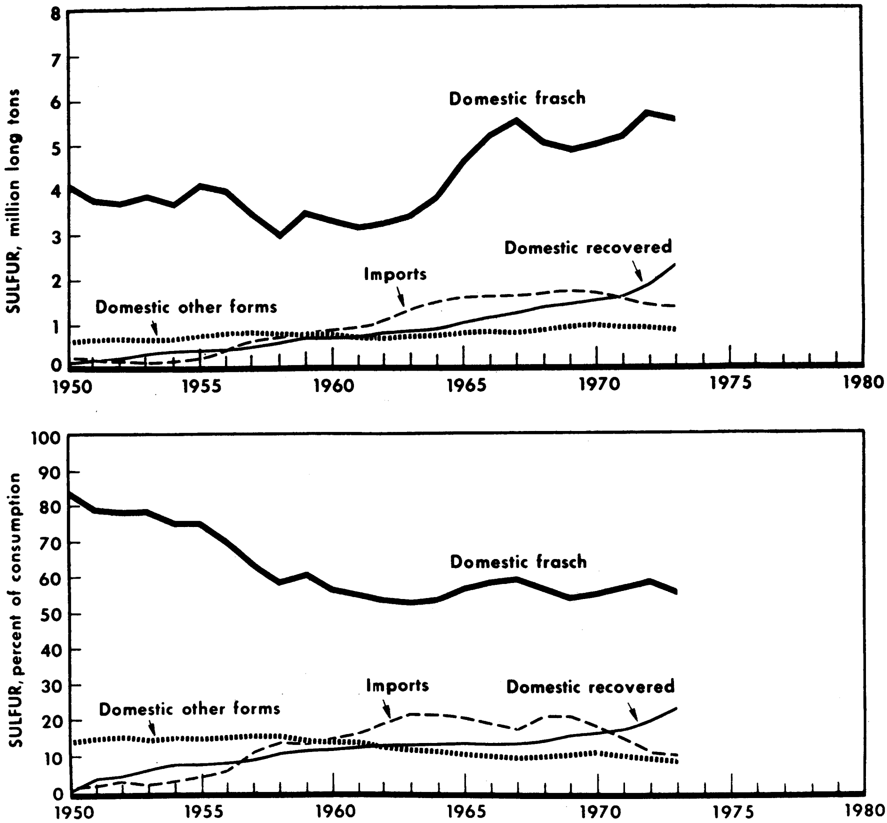

Figure 3.—Trends in the consumption of sulfur in the United States.

those in 1972. The reported sale or use of byproduct sulfuric acid, pyrites, hydrogen sulfide, and sulfur dioxide by domestic producers in the domestic markets decreased by 78,000 tons, or 8%. Imports of elemental sulfur for domestic consumption increased by 34,000 tons, or 3% above imports of elemental sulfur and pyrites for domestic consumption in 1972.

Approximately 90% of the sulfur consumed was in the form of sulfuric acid. The manufacture of fertilizers accounted for approximately 54% of all sulfur consumption. Together, plastic and synthetic products, paper products, paints, nonferrous metal production, and explosives accounted for approximately 21% of demand. The remaining 25% was used for a large number of relatively small individual end uses.

The approximate distribution of consumption was as follows: Southern States (except Florida) 39%; State of Florida 30%; North-Central States 11%; Western States 12%; and Northeastern States 8%.

STOCKS

Yearend producers' stocks of combined Frasch and recovered sulfur were 3% more than those at yearend 1972 because production of Frasch sulfur exceeded combined shipments to the domestic and export markets by 167,000 tons, with the excess being added to the producers' stockpiles. The combined yearend stocks amounted to approximately a 5-month supply based on the 1973 domestic and export demands for domestically produced Frasch and recovered sulfur.

Table 9.—Producers' yearend stocks
(Thousand long tons)

Year	Frasch	Recovered	Total
1969	3,243	95	3,338
1970	3,744	85	3,829
1971	4,023	97	4,120
1972	3,665	r 131	r 3,796
1973	3,816	111	3,927

r Revised.

PRICES

Producers of Frasch and recovered elemental sulfur report the value of their shipments f.o.b. mine or plant. Such values vary widely between different mines or plants, depending upon prevailing selling prices in the markets they individually serve and the transportation costs to these markets.

The values f.o.b. mine or plant do not necessarily reflect the ultimate selling prices because most sales of elemental sulfur, generally in the form of molten sulfur, are made ex-terminal near the point of consumption. Due to the highly competitive nature of the transactions, prices are not generally made available. The trade journal, Sulphur, reported bimonthly on sales prices by areas on the basis of the best information available.

Early in 1973 several major Frasch sulfur producers independently announced increases in the price of liquid sulfur ex-terminals, ranging upward to about $3 per ton in the Tampa, Fla., area, to be effective as soon as contractual agreements permitted. Additional price increases of about $3 per ton, under similar conditions, were announced at midyear 1973.

These Frasch sulfur price increases were accepted by major consumers because they recognized that Frasch sulfur production costs had increased, because they were actively seeking assured forward commitments of sulfur to supply large phosphoric acid plants that were either under construction or in the planning stage, and because the greater profitability of the phosphate fertilizer manufacturing industry allowed them to pay higher prices for sulfur.

However, because of contractual agreements, the higher price levels were only partially effective by midyear and did not generally become fully effective until near yearend. As a result, the sales values of shipments of Frasch sulfur f.o.b. mine during 1973 increased only $1.24 per ton, or 7% more than the prices prevailing during 1972.

By the end of 1973, an increasingly strong demand for sulfur by fertilizer manufacturers created a situation in which sulfur was approaching short supply in the major fertilizer-manufacturing areas. It became evident that this situation, coupled with further increasing costs of producing Frasch sulfur, would lead to price increases in Tampa, Fla., and other fertilizer centers in early 1974.

In contrast to the Frasch industry, with a relatively stable marketing pattern, the recovered sulfur industry experienced marketing problems in some areas of the Nation. Because of regional competitive factors, some areas were able to increase their unit shipment values f.o.b. plant, whereas other areas registered sharp decreases. Overall, the reported unit shipment values in 1973 were slightly lower than those reported in 1972.

Table 10.—Reported sales values of shipments of elemental sulfur, f.o.b. mine or plant
(Dollars per long ton)

Year	Frasch	Recovered	Total
1969	26.60	29.15	27.05
1970	23.65	20.89	23.14
1971	17.50	17.37	17.47
1972	17.39	r 15.60	r 17.03
1973	18.63	15.45	17.84

r Revised.

Source: Producers' reports.

Table 11.—Sulfur prices, liquid, ex-terminal
(Dollars per long ton)

	Yearend 1972	Yearend 1973
Gulf Coast region	24–25	29–30
Tampa, Fla	25	31
South Atlantic region	27–28	32.50–33.50
North Atlantic region	29–30	37.50–38.50
North Central States	24–25	33–36

Source: Sulphur (London).

FOREIGN TRADE

The United States maintained its position as a net exporter of sulfur in 1973. However, net exports were substantially less than in 1972. Exports of sulfur in all forms in 1973 were 4% less than those in 1972, and imports in all forms were 3% more than those in 1972. As a result, total exports of sulfur exceeded total imports by only 555,000 long tons in 1973, as compared to 664,000 tons in 1972, a decrease of 109,000 tons, or 16%.

The maintenance of the export-import balance reflected strenuous efforts on the part of domestic producers to maintain their competitive position in both domestic and world markets in the face of strong foreign competition and low price levels. Favorable factors included limitations on the importation of elemental sulfur from Mexico because of antidumping duties under provisions of the Antidumping Act and a continuing strong demand for sulfur in foreign markets. The European market, in particular, continued to rely upon U.S. Frasch producers as an assured source of supply during a period in which logistic problems limited sulfur exports from Canada, and production problems in Poland made that source of supply uncertain.

Exports were almost entirely in the form of elemental Frasch sulfur. The tonnage of crude sulfur exported during 1973 was 4% less than in 1972. However, the total value increased by 6%, with the average reported value of $17.55 per ton in 1972 increasing to $19.38 per ton in 1973. Together, Belgium and the Netherlands received 63% of these exports, mainly for transshipment to other European Community (EC) countries. Brazil, with 13%, was the third largest customer.

Imports of sulfur consisted largely of recovered sulfur from Canada and Frasch sulfur from Mexico. Imports from Canada in 1973 were 4% more than those in 1972. Imports from Mexico were 12% more than those in 1972, but were only 52% of the average imports during the years 1969 through 1971, prior to the imposition of antidumping duties. However, in the latter part of 1973, with higher prices in the Tampa, Fla., market mitigating the effects of the antidumping duties, imports from Mexico into this area began to increase. There were indications that these conditions would lead to substantial increase in imports from Mexico. The total quantity of elemental sulfur imported in 1973 was 7% more than in 1972, and the total value decreased by 9%. The average declared customs value in 1973 was $12.06 per ton, whereas in 1972 the average was $14.31 per ton.

There were no imports of pyrites from Canada in 1973; shipments were phased out in 1972 because this product was no longer competitive with low-cost domestic elemental sulfur.

Acting under the provisions of the Antidumping Act, the U.S. Government completed an ongoing investigation of the sales of Canadian elemental sulfur within the United States. The investigation was initiated in early 1972, being mainly based on a complaint that sales of Canadian sulfur were being made at less than cost of production.

On January 17, 1973, the U.S. Department of the Treasury announced a 3-month extension of the investigation because certain complex issues had not yet been resolved relating to the treatment of possible sales below cost of production.[3]

On April 19, 1973, the Department of the Treasury announced two determinations.[4] First, the prices at which foreign merchandise is sold in the home market or for exportation to countries other than the United States would be used in determining the "fair value" of such merchandise regardless of whether the prices represented less than the cost of production. Second, it issued a Withholding of Appraisement notice directed against imports of elemental sulfur from Canada on the basis that there were reasonable grounds to believe or suspect that selling prices were below those allowed by the Antidumping Act. The practical effect of these determinations was to limit the investigation to a conventional comparison between purchase prices and home market prices

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[3] U.S. Department of the Treasury. Sulphur From Canada. Notice of Extension of Time for Investigations. Federal Register, v. 38, No. 13, Jan. 19, 1973, p. 1945.

[4] U.S. Department of the Treasury. Sales Below Cost of Production, Antidumping: Fair Value Determination. Elemental Sulfur From Canada, Withholding of Appraisement Notice. Federal Register, v. 38, No. 77, Apr. 23, 1973, pp. 10026–10027.

rather than to consider the cost of production.

On July 20, 1973, the Department of the Treasury announced its determination that elemental sulfur from Canada was being, or was likely to be, sold in the U.S. market at less than fair value within the meaning of the Antidumping Act.[5] On July 26, 1973, the U.S. Tariff Commission announced that, having received this advice from the Department of the Treasury, it was instituting an investigation to determine whether an industry in the United States was being, or was likely to be, injured or prevented from being established by reason of these imports.[6]

The Tariff Commission on October 23, 1973, announced that it had determined by a vote of 3 to 2 that an industry in the United States was likely to be injured by reason of the importation of elemental sulfur from Canada that was being, or was likely to be, sold at less than fair value within the meaning of the Antidumping Act.[7] On December 12, 1973, the Department of the Treasury announced that it was adding elemental sulfur from Canada to the list of findings of dumping currently in effect.[8] These actions made sulfur imports from Canada subject to antidumping duties.

Table 12.—U.S. exports of sulfur

(Thousand long tons and thousand dollars)

Year	Crude		Refined	
	Quantity	Value	Quantity	Value
1969	1,549	57,449	2	334
1970	1,429	33,096	4	955
1971	1,532	27,844	4	1,019
1972	1,847	32,409	5	1,278
1973	1,771	34,330	6	1,461

[5] U.S. Department of the Treasury. Elemental Sulphur From Canada. Antidumping: Determination of Sales at Less Than Fair Value. Federal Register, v. 38, No. 141, July 24, 1973, p. 19844.
[6] U.S. Tariff Commission. Elemental Sulphur From Canada. Notice of Investigation and Hearing. Federal Register, v. 38, No. 146, July 31, 1973, pp. 20381–20382.
[7] U.S. Tariff Commission. Elemental Sulfur From Canada. Determination of Likelihood of Injury. Federal Register, v. 38, No. 206, Oct. 26, 1973, pp. 29655–29657.
[8] U.S. Department of the Treasury. Antidumping. Elemental Sulphur From Canada. Federal Register, v. 38, No. 241, Dec. 17, 1973, p. 34655.

Table 13.—U.S. exports of crude sulfur, by country

(Thousand long tons and thousand dollars)

Destination	1972		1973	
	Quantity	Value	Quantity	Value
Argentina	51	962	39	743
Australia	96	2,126	81	1,924
Belgium-Luxembourg	576	7,832	659	11,389
Brazil	229	4,291	236	4,723
Canada	26	725	45	1,203
Canary Islands	--	--	7	191
Chile	17	294	36	1,120
France	8	154	--	--
Ireland	26	474	26	448
Israel	33	586	7	138
Italy	31	640	41	874
Korea, Republic of	16	307	--	--
Mexico	2	60	1	49
Netherlands	574	10,522	453	8,422
New Zealand	70	1,543	72	1,636
South Africa, Republic of	12	268	(1)	1
Spain	5	108	8	199
Switzerland	5	102	(1)	(1)
Taiwan	--	--	7	202
Tunisia	28	576	--	--
United Kingdom	20	347	43	757
Uruguay	17	332	7	153
Other	5	160	3	158
Total	1,847	32,409	1,771	34,330

[1] Less than ½ unit.

Table 14.—U.S. imports of sulfur [1]
(Thousand long tons and thousand dollars)

Year	Elemental		Pyrites [2]	
	Quantity	Value	Quantity [e]	Value
1969	1,675	57,222	120	NA
1970	1,537	34,149	130	NA
1971	1,299	25,419	130	NA
1972	1,138	16,288	50	NA
1973	1,222	14,742	--	--

[e] Estimate. NA Not available.
[1] Crude sulfur or sulfur content.
[2] From Canada.

Table 15.—U.S. imports of elemental sulfur, by country
(Thousand long tons and thousand dollars)

Country	1972		1973	
	Quantity	Value	Quantity	Value
Canada	868	8,216	905	8,412
Germany, West	(1)	17	1	113
Mexico	269	8,052	302	6,013
Trinidad and Tobago	--	--	14	202
Other [2]	1	3	(1)	2
Total	1,138	16,288	1,222	14,742

[1] Less than ½ unit.
[2] 1971—United Kingdom, Zambia; 1972—Guyana, United Kingdom.

WORLD REVIEW

The world's production of sulfur in all forms increased substantially over that of 1972, mainly because of an increase in the production of Frasch and recovered elemental sulfur. Major increases were shown in the production of Frasch and recovered sulfur in the United States, recovered sulfur in Canada, and Frasch sulfur in Mexico and Poland. Additionally, the U.S.S.R. was reported to have increased its production of sulfur in all forms. For the world as a whole, the production of pyrites remained fairly stable.

World demand for sulfur also increased substantially over that of 1972, primarily because of a continuing upsurge in demand for use in fertilizer manufacturing. However, production exceeded demand by a somewhat wider margin than in 1972 as reflected by an increase in producers' stocks, particularly in the case of Canadian recovered sulfur.

Because of logistic problems that restricted the movement of sulfur from certain major producing areas to world markets, there was more of an effective equilibrium between available supply and consumption than the overall statistics would suggest. These logistic problems, coupled with the increasingly strong demand, created a tight supply position for sulfur in most of the major consuming areas of the world in the latter part of 1973. As a result, sulfur prices began to increase during this period.

There was a continuation of the trend toward a basic restructuring of world sulfur supply sources, with increasingly larger supplies being obtained from secondary sources such as petroleum refineries and plants treating sour natural gas. However, the Frasch sector of the industry, with its well-established production and distribution facilities and ample stocks on hand, continued to maintain its position with consumers as the most reliable source of supply. The pyrites industry continued to become less attractive to the major sulfur-consuming countries of the world as a source of supply.

There was a continuing trend toward the use of liquid sulfur tank ships in international trade and the installation of liquid sulfur terminal facilities at points of consumption.[9] This was being brought about because of environmental problems associated with the storage and shipment of dry bulk elemental sulfur with its associated dust problems, and the preference of consumers for the delivery of liquid sulfur ex-terminals. Further implementation of this method of distribution will require large capital investments by sulfur producers.

Stabilization of conditions in the Middle East and the prospective reopening of the Suez Canal increased the probability that the Persian Gulf area would emerge as a major source of world sulfur supplies. The countries bordering on the Persian Gulf have tremendous reserves of sulfur that could be recovered as a byproduct during the exploitation of their deposits of sour petroleum and sour natural gas. In the past these sulfur resources have only been

[9] Sulphur (London). Seaborne Trade in Liquid Sulphur. No. 108, September–October 1973, pp. 35–40.

exploited to a limited extent. However, with announced plans for large refinery installations, petrochemical complexes, and natural gas liquefaction plants, it appeared inevitable that the production of recovered elemental sulfur would increase very rapidly. Additionally, the reopening of the Suez Canal would permit the marketing of this sulfur in European markets.

Canada.—The Province of Alberta's production of recovered elemental sulfur increased from 6.5 million long tons in 1972 to 7.0 million tons in 1973 as the result of the completion of several new plants. Alberta's shipments of sulfur increased from 3.1 million tons in 1972 to 3.9 million tons in 1973, mainly because of an increase in offshore shipments through the port of Vancouver, British Columbia. With production continuing to exceed shipments by a wide margin, producers' yearend stocks increased from 8.7 million tons in 1972 to 11.8 million tons in 1973. Although producers announced substantial increases in prices in the latter part of 1973, contractual arrangements did not permit them to become effective until after the close of the year. As a result, the value of the marketed sulfur, f.o.b. plant, remained low, in the range of $5.50 to $6.00 per ton for the year as a whole.

With no new major sulfur recovery plant construction currently underway, it appeared that Alberta's recovered sulfur production had leveled off at approximately 7 million tons per year. The rated nameplate capacity of these plants for 1974 was 25,000 tons per day, or approximately 9 million long tons of sulfur per year.[10] However, these plants do not operate at full capacity throughout the year because of the cyclic demand for natural gas and downtime for maintenance.

Efforts were underway to solve logistic problems limiting the shipment of Alberta's sulfur to world markets. One development was the shipment of sulfur to the port of Churchill, Manitoba, for transshipment to Europe during the forthcoming summer shipment season on Hudson Bay. Additionally, consideration was being given to shipping to Great Lake ports, also for transshipment to the European market. It was projected that total sales of Canadian sulfur would reach 4.7 million tons in 1974, with stockpiles accumulating at a slower rate than in previous years and leveling off at around 20 million tons in 1980.[11]

Germany, West.—This nation continued to move toward self-sufficiency in sulfur supply, mainly as the result of an increase in recovered sulfur capacity. Sour natural gas treatment plants in the Ems/Weser zone of northern West Germany at Voigtei, Duste, and Grossenkneten increased production to about 350,000 tons of recovered sulfur per year.[12]

Iraq.—Production of Frasch sulfur at the Mishraq mine of Iraq National Minerals Co. was being expanded from its initial production of 250,000 tons per year to 1 million tons per year. This sulfur was being shipped by rail to the Iraqi port of Umm Qasr on the Persian Gulf near Basrah.[13] While the Mishraq operation is of potential importance as a source of Frasch sulfur supply, inadequate transportation facilities between the mine and the port have been a limiting factor, pending planned improvements to the railroad and port facilities and the purchase of additional liquid tank cars.

Japan.—Following a long-range trend, there was a further restructuring of the Japanese sulfur industry in 1973. Native sulfur ores, formerly a major source of supply, accounted for only an insignificant portion of the nation's sulfur output. Additionally, the pyrites industry was becoming of lesser importance as a source of supply, with a prospect that it would be largely phased out within the next decade. Counterbalancing the declines in the native sulfur ore and pyrites industries has been a very rapid growth in recovered sulfur output at petroleum refineries. Additionally, there has been a rapid growth in the production of sulfuric acid at smelters treating domestic and imported nonferrous sulfide ores and concentrates.

Contrary to general expectations, there was a moderate shortage of sulfur in all forms in 1973. However, it was anticipated that the planned expansion in desulfurization capacity at refineries and pollution control measures would result in an over-

[10] Oilweek (Canada). Gas Processing Plant Capacities 1974. V. 24, No. 49, Jan. 21, 1974, pp. 30–32.
[11] Pearse, G. H. K. Sulphur. Canadian Min. J., v. 95, No. 2, February 1974, p. 33.
[12] Sulphur (London). World Trends. West Germany. No. 109, November–December 1973, p. 7.
[13] Sulphur (London). World Markets. Iraq. No. 106, May–June 1973, p. 10.

supply situation in the near future. It was proposed to alleviate overproduction by promoting exports to Asiatic markets where the competitive power of Japan's product would be enhanced due to her advantageous position as regards transport costs.[14]

Mexico.—Conditions in the Frasch-based sulfur industry improved substantially over those in 1972, with increases in both production and exports. This industry had been adversely affected by the imposition of antidumping duties on the importation of Mexican sulfur into United States; historically, the U.S. market had been Mexico's major customer.

Mexico appeared to have successfully resolved this serious problem by a rather complete reconstruction of its export marketing patterns, with penetrations into the South American and Far East markets. The program was aimed at extending the concept of liquid sulfur transportation to South American markets and possibly to the Far East. Additionally, consideration was given to establishing a sulfur distribution center on the Pacific Coast of Mexico.[15]

Poland.—Poland continued to improve its position as one of the world's largest producers and exporters of elemental sulfur. A reorganization of the industry in the form of further decentralization became effective in late 1973. It was anticipated that decentralization would improve Poland's position in the production and marketing sectors of the industry. Poland's export capability was increased by the addition of a third liquid sulfur tank ship. Additionally, plans were being made for the construction of two additional liquid sulfur tankers with the expectation that they would be placed in operation by 1975.[16]

U.S.S.R.—The production of sulfur in all forms increased substantially over that of 1972. While pyrites was still a substantial source of sulfur production, the U.S.S.R. continued to emphasize the production of native sulfur. The principal native sulfur producing centers continued to be Rozdol and Yavorov (West Ukraine), Gaurdak and Shorsu (Central Asia), and the Volga group of the Kuybyshev sulfur complex. The Rozdol chemical complex was the country's major producer of native sulfur and, with the Gaurdak combine,

[14] Hashimoto, F. Sulfur & Sulfuric Acid. Japan Chemical Review 1974, p. 63.
[15] Page 40 of work cited in footnote 9.
[16] Page 9 of work cited in footnote 12.

Table 16.—Elemental sulfur: World production by country

(Thousand long tons)

Country [1]	1971	1972	1973 p
Native sulfur:			
Frasch:			
Iraq	--	135	389
Mexico	1,074	847	1,520
Poland e	2,165	2,559	3,051
United States	7,025	7,290	7,605
Total	10,264	10,831	12,565
From sulfur ores:			
Argentina	38	42	32
Bolivia (exports)	10	18	56
Chile	105	77	31
China, People's Republic of e	128	128	128
Colombia e	30	32	4
Ecuador e	6	6	6
Indonesia	e 1	2	2
Iran [2]	2	3	e 3
Italy	71	90	79
Japan [3]	64	17	(4)
Mexico	23	21	--
Pakistan	2	3	3
Poland e	505	r 322	434
Taiwan	5	4	6
Turkey	23	21	17
U.S.S.R. e	r 2,067	r 2,165	2,264
Total	r 3,080	2,951	3,065
Total native sulfur	r 13,344	13,782	15,630

See footnotes at end of table.

Table 16.—Elemental sulfur: World production by country—Continued

(Thousand long tons)

Country [1]	1971	1972	1973 [p]
Other elemental sulfur: Recovered:			
Algeria [e] [5]	20	20	20
Austria [6]	3	[e] 3	[e] 3
Belgium [6]	[r] 24	25	25
Brazil [5]	9	9	1
Bulgaria [5]	6	7	[e] 7
Canada [7]	4,720	6,839	7,290
China, People's Republic of [e] [8]	118	118	118
Colombia [e] [5]	3	3	3
Egypt, Arab Republic of [e] [5]	1	1	1
Finland	100	117	121
France [9]	[r] 1,773	1,703	1,775
Germany, East	98	103	108
Germany, West [6]	181	216	327
Hungary	3	6	[e] 8
Iran [9]	487	655	[e] 669
Iraq [e]	59	108	138
Israel [e] [5]	10	10	10
Italy [6]	73	[e] 74	[e] 79
Japan	[10] 339	[10] 474	[4] 670
Kuwait [5]	36	38	[e] 44
Mexico	64	61	63
Netherlands [6]	32	46	48
Netherlands Antilles	26	73	71
Portugal [5]	3	3	3
Saudi Arabia [e] [5]	5	5	5
Singapore [5]	1	6	[e] 6
South Africa, Republic of [5]	25	24	25
Spain [11]	3	4	5
Sweden	5	5	5
Taiwan [5]	[e] 4	[e] 4	8
Trinidad [e] [5]	4	4	4
U.S.S.R.[e]	[r] 1,575	[r] 1,673	1,821
United Kingdom [5]	[r] 43	40	28
United States	1,595	1,950	2,416
Uruguay [e]	([12])	([12])	([12])
Total other elemental sulfur	[r] 11,448	14,427	15,925
Grand total	[r] 24,792	28,209	31,555

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition to countries listed, the Philippines produced less than 100 tons of sulfur annually in 1971 and 1972 from unspecified sources; output in 1973 was reportedly nil.

[2] Year beginning March 21 of year stated.

[3] Includes small quantity of byproduct sulfur recovered from sulfide ores as well as sulfur content of sulfur ores.

[4] Available sources do not divide Japanese 1973 sulfur output by type (ore and other elemental); because output from ore has been declining, the total undivided figure has been reported under other elemental.

[5] From petroleum refining.

[6] Includes in part sulfur content of H_2S converted directly into sulfuric acid.

[7] From processing of natural gas, petroleum, tar sands, and sulfide ores.

[8] From petroleum refining and smelting of sulfide ores.

[9] From petroleum refining and natural gas processing.

[10] From petroleum refineries only. Excludes an unreported quantity recovered from sulfide ores, which is included above (see footnote 4).

[11] From distillation of petroleum and lignite and from reduction of SO_2 gas.

[12] Less than ½ unit.

provided the bulk of the country's sulfur requirements. Output of sulfur at Gaurdak was expected to increase substantially during the next few years.

Increasing attention was also being given to the recovery of secondary sulfur. This included the production of recovered elemental sulfur at refineries and natural gas processing plants, and the production of sulfuric acid at nonferrous metal smelters.

Table 17.—World production of pyrites (including cupreous pyrites)
(Thousand long tons)

Country [1]	1971		1972		1973 [p]	
	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
North America:						
Canada (shipments)	284	[e] 128	112	[e] 51	120	[e] 55
United States [2]	808	316	741	283	559	212
Europe:						
Bulgaria [e]	[r] 150	63	[r] 150	63	150	63
Czechoslovakia [e]	[r] 350	[r] 150	[r] 350	[r] 150	350	150
Finland	852	383	843	379	765	344
France	80	[r] 43	33	17	--	--
Germany, East [e]	[r] 140	57	[r] 140	57	140	57
Germany, West	487	216	415	187	[e] 537	[e] 242
Greece	204	92	227	102	[e] 226	[e] 102
Hungary [e]	7	3	7	3	7	3
Italy	[r] 1,479	[r] 636	1,361	612	1,151	506
Norway	766	356	782	364	780	363
Portugal	[r] 550	[r] 245	544	239	524	231
Romania [e]	[r] 830	[r] 350	[r] 830	[r] 350	860	370
Spain	[r] 2,402	[r] 1,124	2,106	985	2,153	990
Sweden	582	[r] 293	[r] 479	[r] 246	[e] 669	[e] 344
U.S.S.R. [e]	[r] 6,900	[r] 3,200	[r] 7,100	[r] 3,300	7,200	3,400
Yugoslavia	[r] 272	[r] [e] 114	227	[e] 95	214	[e] 90
Africa:						
Algeria	27	12	27	13	[e] 30	[e] 14
Morocco (pyrrhotite)	434	[r] 113	423	131	401	132
Rhodesia, Southern [e]	72	30	72	30	72	30
South Africa, Republic of	738	295	432	173	542	217
South-West Africa	14	6	--	--	12	5
Asia:						
China, People's Republic of [e]	[r] 2,000	[r] 900	[r] 2,000	[r] 900	2,000	900
Cyprus	[r] 899	[r] 423	685	323	[3] 391	[3] 184
India	40	15	30	11	41	15
Japan	2,306	1,092	1,555	755	1,255	560
Korea, North [e]	[r] 500	[r] 200	[r] 500	[r] 200	500	200
Korea, Republic of	NA	NA	1	(4)	1	(4)
Philippines	235	109	252	117	124	[e] 57
Taiwan	45	[e] 17	30	[e] 11	11	[e] 4
Turkey	58	26	76	35	43	20
Oceania: Australia	[r] 231	[r] 105	253	119	[e] 210	[e] 100
Total	[r] 24,742	[r] 11,112	22,783	10,301	22,038	9,960

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.
[1] Pyrites is produced in Cuba, but there is too little information to estimate production.
[2] Sold and used.
[3] Exports.
[4] Less than ½ unit.

TECHNOLOGY

The energy crisis combined with environmental goals to force a reappraisal of prospects for sulfur recovery from new sources. Most of the reviews and research published during the year were directed towards various scrubbing systems, designed to be added on to existing powerplants, or industrial plants, to reduce SO_2 emissions to levels called for in current regulations. Among these systems, alkaline scrubbing with lime or limestone was far in advance in respect to research performed and experimental installations operating. Nevertheless, it was still beset with severe problems of cost, reliability, and waste disposal; thus recovery systems in which the scrubbing medium is circulated and a useful sulfur product is obtained received increasing attention.

During the year some 26 pilot installations were operated to test lime or limestone scrubbing. Results were inconclusive. Few, if any, of the plants operated with the reliability needed in expensive full-scale units. Utilities companies showed some reluctance to commit large sums of money to scrubbing plants that might be obsolete before they were amortized. The Environmental Protection Agency (EPA), with support from environmentalist groups, nevertheless pushed ahead to attain 1977 environmental goals, modified only by temporary reprieves to meet fuels shortages. The Office of Management and Budget, on the other hand, reported that part of energy research funds would be used to examine the validity of present sulfur emission standards.[17]

Energy problems, which became more pressing late in the year with the Arab oil embargo, increased the likelihood that coal would be called upon to supply an increasing share of the fuel market to replace, in part, petroleum and natural gas. The increased attention to coal conversion emphasized the attractiveness of sulfur removal from fossil fuels at the time of conversion, rather than from the much larger volumes of stack gas; commercial processes are available to recover sulfur produced as hydrogen sulfide, the form in which most sulfur leaves the fuel conversion vessel.

The Office of Coal Research (OCR) of the U.S. Department of the Interior sponsored research into methods of removing sulfur from coal before and during combustion.[18]

The solvent-refined-coal (SRC) pilot plant being constructed for OCR at Fort Lewis, Wash., by the Pittsburgh and Midway Coal Mining Co. was almost complete by the end of 1973. Early tests of this process indicated that it would remove all the inorganic sulfur and 60% to 70% of the organic sulfur in the coal. Oklahoma State University was studying the removal of sulfur from coal-derived liquids in the SRC process. At the Colorado School of Mines, the solvent-refining technique was studied. Experiments underway centered around the conditions necessary to maximize the removal of sulfur.

Research on a clean coke process was carried out by the United States Steel Corp. under a continuing OCR contract. According to the process design, raw coal from the mine is split into two approximately equal portions; one portion is carbonized, whereby it is converted to low-sulfur char, and the other is processed in the hydrogenation section where it is converted to a liquid and a gas rich in light paraffins. Gases from the two sections are combined, and sulfur, among other products, is removed. The main products are metallurgical coke and chemicals.

Another successful year of char-oil-energy development (COED) pilot plant operations was completed during 1973 by the FMC Corp. under contract to OCR. The process is a pyrolysis of the coal feed at atmospheric pressure. In 1973 the plant feed consisted of two high-volatile D bituminous coals. The COED process yields synthetic crude and gas with a heating value of approximately 500 Btu per cubic foot. Sulfur can be removed from the gas by commercial processes. The Ralph M. Parsons Co., under separate contract to OCR, started a commercial design for a COED process complex.

Air Products and Chemicals, Inc., worked on a process to remove sulfur from producer gas in a fixed bed of lime or calcined dolomite. Work proceeded on phase I during the year involving the study of limestone to determine the type most suitable.

In work on an advanced coal gasification system for electric power generation, the Westinghouse Electric Corp., in a contract with OCR, used a lime sorbent in a recirculating bed devolatilizer and desulfurizer to convert the hydrogen sulfide formed into calcium sulfide, which was removed as the spent sorbent.

The Battelle Memorial Institute continued tests on a fuel gas scrubbing process to remove sulfur dioxide, using a molten mixture of lithium carbonate, sodium carbonate, potassium carbonate, and calcium carbonate as the working fluid.

OCR also requested during the year the reactivation of the Cresap, W.Va., facility for further testing of processes to produce low-sulfur fuel oil from Eastern high-sulfur coals. The Cresap pilot plant was originally sponsored under a contract with Consolidation Coal Co. from 1962 to 1969, being then known as Project Gasoline.

The Federal Bureau of Mines continued development of the citrate system for sulfur dioxide removal from stack gases.[19] A pilot plant to test the process was completed in December 1973 at the Bunker Hill Company lead smelter at Kellogg, Idaho. Preliminary test results were encouraging. The same process was tested in a pilot plant at Terre Haute, Ind., by a consortium of Arthur G. McKee & Co., Peabody Engineering Co., and Chas. Pfizer & Co.

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[17] Coal Mining and Processing. V. 11, No. 1, January 1974, p. 32.

[18] U.S. Office of Coal Research. Coal Technology: Key to Clean Energy. Annual Report, 1973-74, 145 pp.

[19] Rosenbaum, J. B., W. A McKinney, H R. Beard, L Crocker. and W. I. Nissen. Sulfur Dioxide Emission Control by Hydrogen Sulfide Reaction in Aqueous Solution. The Citrate System. BuMines RI 7774. 1973. 31 pp.

The Bureau of Mines published a survey of the chemistry of sulfur dioxide in various processes tested to remove it from stack gases.[20]

A major symposium [21] was organized by the EPA to consider the state of the art of flue gas desulfurization. In the keynote address, an EPA official presented data indicating that elevated levels of SO_2 concentration lead to increased morbidity and mortality, and that suspended sulfates also were associated with heart and lung ailments.[22] Adverse health consequences were stated to be associated with SO_2 exposures in the range of 80 to 120 parts per million for 1 or more days.

An analysis was presented of costs of flue gas desulfurization in fossil fuel boiler plants.[23] It was concluded that desulfurization can be applied to 75% of existing fossil fuel utility capacity at an annualized cost of 1.5 to 3.0 mills per kilowatt-hour. Regenerative processes, which produce sulfur and recycle the scrubbing medium, are generally less costly than throwaway processes since waste disposal costs about $3 per ton of wet sludge.

Another limiting factor on the selection of throwaway processes for stack gas desulfurization would be the area needed to dispose of the resultant sludge; if the area is too large, regenerative processes will be mandatory. An estimate was made of this area. Assuming 3.5% sulfur in the coal and 50% solids in the sludge, lime scrubbing was found to require approximately 8,600 acre-feet for each 1,000 megawatts in the course of 20 years of operation; limestone scrubbing would require about 10,800 acre-feet per 1,000 megawatts in 20 years. It was estimated that 20,000 megawatts could be equipped with scrubbing systems by 1975, and perhaps 50,000 megawatts actually would be equipped by 1977.[24] This latter figure would require 3 to 4 square miles of disposal area per year, covered to an average depth of 10 feet. If the entire present U.S. coal generating capacity, about 200,000 megawatts at an average of 2% sulfur in the coal, were controlled in this way, it would require about 10 square miles per year of disposal area.

Additional papers presented discussed the status of various alkaline scrubbing processes in the United States and abroad, including pilot plant experience, and advanced concepts such as scrubbing with ammoniacal solutions, double alkali processes, molten salt scrubbing, and dry adsorption. In summing up, one of the session chairmen concluded that scrubbing technology was feasible in commercial-sized installations, but that certain problems remained to be solved. This conclusion supported that of the Sulfur Oxide Control Technology Assessment Panel (SOCTAP).

SOCTAP, a Federal interagency committee, released its final report.[25] It was concluded that sulfur dioxide removal from stack gases is technologically feasible in commercial-sized installations, and that a large fraction of the Nation's coal-fired steam-electric plants can ultimately be fitted with commercially available stack gas cleaning systems. Four processes were considered sufficiently developed to potentially desulfurize flue gas. These were wet lime/limestone scrubbing, magnesium oxide scrubbing, catalytic oxidation, and wet sodium-base scrubbing with regeneration. An additional process, the double alkali process, was considered potentially important.

A new pilot plant was completed by the Tennessee Valley Authority (TVA) at its generating plant at Colbert, Ala., to test the ammonium sulfate regeneration process in connection with ammonia-based scrubbing of sulfur oxides from stack gases. The ammonium sulfite formed is acidified with ammonium bisulfate, releasing SO_2; the ammonia and bisulfate are regenerated from the resultant sulfate with heat.[26]

The elemental sulfur pilot plant of American Smelting and Refining Co. and Phelps Dodge Corp. at El Paso resumed

[20] Haas, L. A. Sulfur Dioxide: Its Chemistry as Related to Methods for Removing It From Waste Gases. BuMines IC 8608, 1973, 19 pp.

[21] Office of Research and Development, National Environmental Research Center, U.S. Environmental Protection Agency (Research Triangle Park, N.C.). Proceedings: Flue Gas Desulfurization Symposium, New Orleans, May 14–17, 1973. EPA-650/2-73-038, December 1973.

[22] Newill, V. A. and J. D. French. Health Rationale for Strict Control of Sulfur Oxide Emissions. Pp. 1–12 of work cited in footnote 21.

[23] Rochelle, G. T. Economics of Flue Gas Desulfurization. Pp. 103–132 of work cited in footnote 21.

[24] Jones, J. W. and R. D. Stern. Waste Products From Throwaway Flue Gas Cleaning Processes—Ecologically Sound Treatment and Disposal. Pp. 187–234 of work cited in footnote 21.

[25] Sulfur Oxide Control Technology Assessment Panel (SOCTAP). Projected Utilization of Stack Gas Cleaning Systems by Steam-Electric Plants. Final report submitted to the Federal Interagency Committee, Evaluation of State Air Implementation Plans, Apr. 15, 1973, 93 pp.

[26] Tennessee Valley Authority, National Fertilizer Development Center. 1973 Annual Report. 21 pp.

operations after replacing the primary reactor. The plant had been closed down since early in 1972.[27] The process was designed to produce sulfur from smelter stack gases by direct reduction with natural gas. It is considered to be suitable for stack gases containing about 12% SO_2, such as those produced in flash smelting or other continuous smelting of base metal ores.

Sulfur recovery from base metal smelter emissions has been hampered by the intermittent nature of such operations. Attention during the year was focused on continuous smelting to alleviate this problem. The Mitsubishi, Worcra, and Noranda processes were basically continuous smelting with strong off gases.[28]

An experimental sodium-sulfur cell using a beta alumina electrolyte was described.[29] Characteristics of the anodic and cathodic reactants allow one to expect batteries with an energy density higher than 150 watt hours per kilogram, which makes them a promising energy source for urban electric vehicles. The average lifetime to date has been 90 ampere hours per square centimeter (A-hr/cm^2), with an upper limit of 150 A-hr/cm^2. It seems necessary to double this figure before a battery in the range of a few hundred watts can be constructed.

The Bureau of Mines developed a rapid quantitative analysis for pyrite in coal by X-ray diffraction with computerized data procession.[30] Noncrystalline sulfur is not detected. Pyrite in the usual range of 0.1% to 3% in coal can be detected quantitatively.

The TVA found that application of molten sulfur in producing sulfur-coated-urea (SCU) fertilizer substantially improved the coating process. Improvements included better coating efficiency and uniformity, less dust and mist formation, simplified coating drum design, and decreased requirement for preheating the urea. Crop yields continued to show promise for SCU, including more uniform plant growth, lower application costs, and higher yields under some conditions. On certain crops, such as forages and long-season horticultural crops, results of trials showed SCU superior to soluble nitrogen.[31]

A survey of users of sulfur dioxide and nitrogen oxides monitoring equipment revealed that in recent years high and variable levels of SO_2 in stack emissions have been successfully monitored by measurements of the strong ultraviolet light absorption of this compound. Measuring techniques commonly used for ambient monitoring had earlier been applied with only marginal success to stack monitoring.[32]

The present worldwide oversupply of sulfur, together with the projection that environmental controls would create an even greater oversupply position, was responsible for the expansion of a large number of research programs designed to develop new uses for sulfur of a magnitude that would alleviate this situation. These research projects were largely Government sponsored. Additionally, however, trade organizations, sulfur-producing companies, universities, and independent laboratories pursued programs designed not only to develop novel uses for sulfur, but to investigate the basic properties of sulfur as they might relate to new uses.

The Bureau of Mines continued its broadly based sulfur utilization program covering asphalt-sulfur paving materials, sulfur applications for land pollution abatement, characterization of construction materials containing sulfur, and new metallurgical applications for sulfuric acid. Under one segment of the Bureau's program, the Texas A & M Research Foundation reported on the beneficial use of sulfur in sulfur-asphalt pavements. This report, covering the first phase of a research project jointly funded by the Bureau of Mines and The Sulphur Institute, described familiarization and verification of existing technology, literature search and patent review, and preliminary design, construction, and quality control procedures.[33]

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[27] Mining Congress Journal. V. 50, No. 12, December 1973, p. 7.

[28] Price, F. C. Copper Technology on the Move. Eng. and Min. J., v. 174, No. 4, April 1973, pp. RR–HHH.

[29] Fally, J. Some Aspects of Sodium-Sulfur Cell Operation. J. Electrochem. Soc.: Electrochem. Sci. and Technol., v. 120, No. 10, October 1973, pp. 1292–1295.

[30] Schehl, R. R., and R. A. Friedel. Computerized System for Quantitative X-Ray Diffraction Analysis of Pyrite in Coal. BuMines TPR 71, 1973, 9 pp.

[31] Work cited in footnote 26.

[32] Barrett, D. F., and J. R. Small. Emission Monitoring of SO^2 and NO_x. Chem. Eng. Prog., v. 60, No. 12, December 1973, pp. 35–38.

[33] Galloway, B. M., and D. Saylak. Beneficial Use of Sulfur in Sulfur-Asphalt Pavements (in three volumes). Texas A & M Research Foundation, January 1974, 185 pp.

The Sulphur Institute Journal described a number of developments in new uses for sulfur.[34] Subject matters covered included the construction of a concrete block structure by the Bureau of Mines, using a sulfur-fiberglass formulation, research on sulfur concretes at the University of Calgary, Canada, the development of sulfur-asphalt materials by the Société Nationale des Pétroles D'Aquitaine of France, and the characterization of sulfur coatings on urea by TVA.

The Sulphur Development Institute of Canada initiated a large-scale research program designed to develop new uses for sulfur. Financing in the amount of $1 million per year for 3 years was provided by the Federal Government of Canada, the Provincial Government of Alberta, and recovered-sulfur producers in Alberta, Canada.

[34] Sulphur Institute Journal. V. 9, No. 3–4, Fall–Winter 1973, 21 pp.

Talc, Soapstone, and Pyrophyllite

By J. Robert Wells [1]

Talc-group minerals were produced and consumed in 1973, both in the United States and worldwide, at an annual rate that was substantially greater, measured by both quantity and total value, than any previously recorded. The thriving tone of the industry was notable considering the negative influence of the mostly unjustified health-hazard uncertainties spilling over onto talc because of its acknowledged genetic and geological associations with some of the materials classified as asbestos. One such material is tremolite, which sometimes appears with a fibrous structure similar to that of the true asbestos minerals exemplified by chrysotile, and which may be found as a minor-to-major component in some commercial talc deposits.

The characteristic crystal form of the mineral talc is platy—foliated or tabular with poorly defined rhombic or hexagonal outlines—but talc, in certain deposits that also contain tremolite, may occur to some extent as a pseudomorphic replacement after that mineral. Mixtures of talc with 30% or more tremolite have been found to serve better in some specific applications than pure talc itself, with the result that the terms "fibrous talc" and "tremolitic talc" have become quite firmly implanted in the vocabulary of the industry and even appear without qualification in some mineralogical texts. Illustrative of the confusion that can follow from this imprecise terminology is the following statement taken from an item in a nationally circulated hobby-oriented magazine: "Tremolite, better known as talc, is a soft mineral and has a smooth feel when rubbed between the fingers. Ground, it is used for talcum powder." [2]

Legislation and Government Programs.—Defense materials inventories prepared by the General Services Administration showed that Government holdings as of December 31, 1973, included 1,170 short tons of talc (steatite, block or lump, purchased in compliance with a stockpile objective at $390.51 per ton) and 3,900 short tons of talc (steatite, ground, acquired in nonstockpile transactions at a cost of $59.26 per ton). During calendar 1973, 10 tons of the block, valued at $3,300, was sold from inventory, and arrangements were made for the disposal of 1,000 tons of the ground material, leaving 1,170 tons of block and 2,900 tons of ground talc listed as uncommitted excess at yearend.

The Office of Minerals Exploration, Geological Survey, offered to grant loans of up to 50% of approved exploration costs for eligible deposits of block steatite talc, but no loans for that purpose were made in 1973. The allowable depletion rates for talc, established by the Tax Reform Act of 1969 and unchanged through 1973, were 22% on production of block steatite talc of domestic origin and 14% on foreign production of the same material, which rate applied also to production of all other classes of talc from all sources.

Under terms of a regulatory ruling proposed by the Food and Drug Administration, U.S. Department of Health, Education, and Welfare, any talc to be approved for use in the manufacture and processing of drugs or in the packaging of foods would have to be tested by a proposed analytical method based on optical microscopy with polarized light (validation pending) and shown to be as nearly free of asbestos particles as is attainable. Quantitatively, talc for these applications that is not shown to be at least 99.9% free of amphibole types of asbestos fibers and at least 99.99% free of chrysotile asbestos fibers would be deemed adulterated in violation of section 501(a) of the Federal Food, Drug, and Cosmetic Act.[3]

[1] Physical scientist, Division of Nonmetallic Minerals—Mineral Supply.
[2] Gems and Minerals. Field Trip Vignette: New York. No. 434, November 1973, p. 46.
[3] Federal Register. V. 38, No. 188, Sept. 28, 1973, pp. 27076–27081.

Table 1.—Salient talc, soapstone, and pyrophyllite statistics

(Thousand short tons and thousand dollars)

	1969	1970	1971	1972	1973
United States:					
Mine production	1,029	1,028	1,037	1,107	1,247
Value	$7,508	$7,773	$7,634	r $7,828	$9,144
Sold by producers	985	948	979	1,084	1,184
Value	$26,294	$25,980	$26,936	$33,709	$32,226
Exports [1]	69	105	136	171	180
Value	$3,713	$5,739	$4,844	$5,791	$6,618
Imports for consumption	20	30	17	29	23
Value	$749	$1,294	$745	$1,669	$1,658
Apparent consumption	936	873	860	942	1,027
World: Production	5,162	5,316	r 5,221	r 5,241	5,666

r Revised.
[1] Excludes powders—talcum (in package), face, and compact.

Under the sponsorship of the U.S. Department of the Interior, the Bureau of Mines Division of Health, Metal, and Nonmetal Mine Health and Safety, held an open symposium on May 8, 1973, for the purpose of assembling information concerning hazards to workers' health posed by dusts generated in the production and processing of the different varieties of industrial talc. A stated objective of the conference, which was held in the auditorium of the Department of the Interior in Washington, D.C., was to determine whether exposure to these types of dust present health hazards similar to those from the mineralogically related substances known collectively as asbestos. The session was well attended and featured oral and visual presentations (followed by opportunities for questions, answers, and general discussion) by representatives of the sponsoring agency, the talc industry, and various health-oriented organizations. Publication of the symposium proceedings and attendance roster was postponed because of a Departmental reorganization, in which the functions of the Metal and Nonmetal Mine Health and Safety division were transferred to the Mining Enforcement and Safety Administration (MESA), also an agency of the Interior Department but separate from the Bureau of Mines.

DOMESTIC PRODUCTION

Mine production of crude talc and related minerals in the United States established new records in 1973 in both tonnage and total value, topping by 13% and 17%, respectively, the previous high marks reached in 1972.

Talc-group minerals were produced from a total of 51 mines distributed throughout 14 States. Talc or soapstone was mined at one or more locations in each of those States; domestic production of pyrophyllite was limited, as in 1972, to the output of just six mines, all in North Carolina. The six leaders among the talc-group producing States (Vermont, New York, Texas, Montana, California, and North Carolina, ranked in descending order by tonnage—New York, Montana, California, Vermont, Texas, and North Carolina, by value) jointly supplied 95% of the 1973 total domestic output. New York, the foremost producing State throughout most of the industry's history, remained in first place with regard to total value, but slipped in 1973 to second place in terms of tonnage.

The 10 largest domestic producers of talc-group minerals in 1973, listed alphabetically, were Cyprus Mines Corp., United Sierra Division, with mines in California, Montana, and Texas; Eastern Magnesia Talc Co. in Vermont; International Talc Co., Inc., in New York; Johns-Manville Corp. (successor to L. Grantham Corp.) in California; Pfizer Inc., Minerals, Pigments & Metals Division, in California and Montana; Piedmont Minerals Co., Inc., in North Carolina; Southern Clay Products, Inc., in Texas; R. T. Vanderbilt Co., Inc., in California and New York; Westex Talc Co. in Texas; and Windsor Minerals, Inc., in Vermont. Those firms supplied 85% of the 1973 tonnage (83% of the total value), and the combined outputs of about 20 smaller producers made up the remainder.

Talc minerals were ground for sale or industrial use in 1973 in approximately 35 mills operated by 29 companies in 11 States. Talc or soapstone mined in Nevada and

Washington was shipped to other States for grinding, and talc from outside sources was ground in Nebraska, where there was no mine production.

Noteworthy among 1973 events in the talc industry were major expansions, especially of ultrafine-grinding facilities, on the part of several important producers in the western United States.

Table 2.—Talc, soapstone, and pyrophyllite produced in the United States, by State

State	1972 Quantity (short tons)	1972 Value (thousands)	1973 Quantity (short tons)	1973 Value (thousands)
California	155,155	$1,186	179,191	$1,501
Georgia	45,842	338	38,000	114
North Carolina	89,334	594	95,833	1,094
Texas	221,022	1,262	232,514	1,246
Vermont	180,239	1,326	251,087	1,497
Virginia	W	W	4,600	12
Other States [1]	415,812	r 3,122	445,309	3,681
Total	1,107,404	r 7,828	1,246,534	[2] 9,144

r Revised. W Withheld to avoid disclosing individual company confidential data; included with "Other States."
[1] Includes Alabama, Arkansas, Maryland, Montana, Nevada, New York, Oregon, Washington, and States indicated by symbol W.
[2] Data does not add to total shown because of independent rounding.

Table 3.—Talc, soapstone, and pyrophyllite sold or used by producers in the United States, by class

(Thousand short tons and thousand dollars)

Year	Crude Quantity	Crude Value	Ground Quantity	Ground Value	Total [1] Quantity	Total [1] Value
1969	81	362	904	25,931	985	26,294
1970	96	572	852	25,407	948	25,980
1971	132	789	847	26,147	979	26,936
1972	90	521	994	33,188	1,084	33,709
1973	118	918	1,066	31,308	1,184	32,226

[1] Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Apparent domestic consumption of crude and ground talc, soapstone, and pyrophyllite (total sales plus imports minus exports) passed an important milestone in 1973, the first 1-million-ton-per-year total under that heading in the history of the industry. Reported 1973 sales of ground material were 7% more in tonnage than in 1972, but the average unit value declined moderately, and the total value was 6% below that of 1972. Approximately 29% of the total quantity of talc-group minerals sold or used by domestic producers in 1973 was consumed in the manufacture of ceramics, 15% was used in paint, and another 15% was exported. An assessment of talc's future as an ingredient in high-quality paints and the special properties making the mineral virtually irreplaceable in that application were subjects dealt with in two industrial journal articles.[4]

The 1973 end-use distribution showed a 37% increase in talc utilization for papermaking, 7% of the total, compared with 5% in each of the 2 preceding years. It is no doubt significant in this regard that a number of talc processors in the western United States were pushing up their capacity to supply the ultrafine grades of material especially required by pulp and paper manufacturers for pitch control.

[4] American Paint Journal. Growth for Extender, Filler Pigments Forecast by Kline. V. 58, No. 15, Oct. 29, 1973, pp. 52–53.
O'Brien, G. J. Large Reserves—Good Replacement for Short Extenders. Am. Paint J., v. 58, No. 22 (Convention Daily), Nov. 17, 1973, p. 16.

Table 4.—Pyrophyllite[1] produced and sold by producers in the United States

Year	Production (short tons)	Total sales: Short tons	Total sales: Value (thousands)
1969	104,347	110,816	$1,632
1970	120,077	95,735	1,317
1971	101,030	90,477	1,155
1972	W	90,482	1,236
1973	W	113,019	1,469

W Withheld to avoid disclosing individual company confidential data.
[1] Includes sericite schist (1969–70).

Table 5.—Talc, soapstone, and pyrophyllite sold or used by producers in the United States, by use

(Short tons)

Use	1972	1973
Ceramics	329,406	346,254
Paint	173,663	178,352
Toilet preparations	r 40,000	40,006
Exports	r 171,007	180,102
Insecticides	65,465	43,404
Paper	58,505	79,995
Refractories	40,119	54,384
Rubber	36,215	31,646
Roofing	32,913	30,557
Textiles	12,010	8,193
Asphalt filler	11,769	13,039
Other uses[1]	r 113,140	178,546
Total	1,084,212	1,184,478

r Revised.
[1] Includes plastics, stucco, floor tile, foundry facings, rice polishing, crayons, art sculpture, and other uses.

STOCKS

According to estimates based on data reported by producers, the total quantity of crude, ground, and partly processed talc, soapstone, and pyrophyllite on hand in the United States (that is, mined but not yet sold or used) was approximately 157,000 tons on December 31, 1973, compared with 167,000 tons on that date in 1972.

PRICES

Engineering and Mining Journal, December 1973, quoted prices for domestic ground talc in carload lots, f.o.b. mine or mill, containers included, per short ton, as follows:

Vermont:	
98% through 325 mesh, bulk	$20.00
99.99% through 325 mesh, bags:	
Dry processed	58.00
Water beneficiated	86.00
New York:	
96% through 200 mesh	28.00
99.9% through 325 mesh	44.50
100% through 325 mesh, fluid energy ground	$80.00–90.00
California:	
Standard	37.00– 53.00
Fractionated	37.00– 71.00
Micronized	62.00–104.00
Cosmetic-steatite	44.00– 65.00
Georgia:	
98% through 200 mesh	14.00
99% through 325 mesh	25.00
100% through 325 mesh, fluid energy ground	75.00

American Paint Journal, December 1973, listed the following prices per ton for paint-grade talcs in carload lots:

California: 325 mesh, bags, mill:	
Fibrous, white, high oil absorption	$34.00–$37.00
Semifibrous, medium oil absorption	32.00– 73.95
Montana: Ultrafine grind, f.o.b. mill	70.00
New York: Fibrous and semifibrous, bags, mill:	
98% through 325 mesh	31.00
99.4% through 325 mesh	40.00
Trace retained on 325 mesh	80.00
Fine micron talcs (origin not specified)	68.00–111.50

The price range quoted in Chemical Marketing Reporter, December 31, 1973, for carload lots of imported Canadian talc, ground, in bags, was from $20 to $35 per ton, f.o.b. works.

The equivalents in dollars per short ton of price ranges for steatite talc, c.i.f. main European ports, quoted by Industrial Minerals (London), December 1973, were as follows:

Norwegian:	
Ground	$24.00–$29.00
Micronized	43.00– 79.00
French: Fine ground	39.00– 89.00
Italian: Cosmetic grade	66.00–103.00
Chinese	49.00– 65.00

FOREIGN TRADE

Exports.—The quantity of talc-group minerals exported from the United States in 1973 was 5% more than in 1972, and the total value was 14% higher, establishing new alltime highs in both respects. The largest share of the exported material was shipped to Mexico, followed in descending order by Canada, Belgium, Japan, Venezuela, and the United Kingdom. Shipments to those six destinations accounted for 90% of the 1973 total, and the remaining 10% was distributed among about 50 other countries.

Imports.—The tonnage of unmanufactured talc imported by the United States in 1973 was about one-fifth less than the corresponding figure for 1972, but the total value was only fractionally lower. Noteworthy among 1973 imports was an item in the Census Bureau's classification "Talc, steatite, and soapstone and articles of these, not specially provided for" that was listed as being valued at $150,000 and as having originated in the People's Republic of China.

Tariffs.—Schedules applicable throughout 1973 provided for import duties on the various classifications of talc as follows: Crude and not ground, 0.02 cent per pound; ground, washed, powdered, or pulverized, 6% ad valorem; cut or sawed, or in blanks, crayons, cubes, disks, or other forms, 0.2 cent per pound; and other, not specially provided for, 12% ad valorem.

Table 6.—U.S. exports of talc, soapstone, and pyrophyllite, crude and ground

(Thousand short tons and thousand dollars)

Year	Quantity	Value
1971	136	4,844
1972	171	5,791
1973	180	6,618

Table 7.—U.S. imports for consumption of talc, steatite or soapstone, by class and country

Year and country	Crude and unground: Quantity (short tons)	Crude and unground: Value (thousands)	Ground, washed, powdered or pulverized: Quantity (short tons)	Ground, washed, powdered or pulverized: Value (thousands)	Cut and sawed: Quantity (short tons)	Cut and sawed: Value (thousands)	Total unmanufactured: Quantity (short tons)	Total unmanufactured: Value[1] (thousands)
1971	7,577	$190	9,511	$379	294	$176	17,382	$745
1972:								
Canada	3,639	37	3,027	93	7	4	6,673	134
France	--	--	3,652	135	--	--	3,652	135
Hong Kong	--	--	--	--	171	92	171	92
India	--	--	--	--	3	1	3	1
Italy	15,102	833	748	73	--	--	15,850	906
Japan	--	--	--	--	502	324	502	324
Korea, Republic of	--	--	2,044	48	52	28	2,096	76
Thailand	138	1	--	--	--	--	138	1
Total	18,879	871	9,471	349	735	449	29,085	1,669
1973:								
Brazil	--	--	141	14	--	--	141	14
Canada	4,424	44	3,994	138	5	1	8,423	183
France	2,536	46	1,821	98	--	--	4,357	144
Hong Kong	--	--	--	--	190	112	190	112
India	--	--	--	--	9	5	9	5
Italy	7,507	600	1,080	129	--	--	8,587	729
Japan	--	--	--	--	433	344	433	344
Korea, Republic of	--	--	734	57	119	70	853	127
Total	14,467	690	7,770	436	756	532	22,993	1,658

[1] Does not include talc, n.s.p.f.: 1971, $17,997; 1972, $128,925; 1973, $230,997.

WORLD REVIEW

Australia.—The Australian Department of Overseas Trade stated that a newly launched enterprise, that of Westside Mines N.L., at a site south of the Murchison River and near Meekatharra in Western Australia, is expected to develop into one of the world's foremost sources of white micaceous talc in grades especially suited for use by the cosmetic, paper, paint, and rubber industries. The Westside deposit's proved reserves of high-quality mineral were said to amount to more than 1 million tons, with at least double that quantity indicated as existing.

Canada.—Talc was produced in 1973 in two provinces—in Ontario by Canada Talc Industries, Ltd., from underground workings at Madoc; and in Quebec by Baker Talc, Ltd., from an underground mine at South Bolton and by Broughton Soapstone & Quarry Co., Ltd., from an open pit facilitiy near Broughton Station. Expectations for a second producer in Ontario received a setback when Canadian Johns-Manville Co., Ltd., terminated an agreement to assist Canadian Magnesite Mines, Ltd., in the installation of a flotation plant for the beneficiation of talc and magnesite ore from a property in the Timmins area. Both of the companies operating in Quebec, in addition to various grades of ground talc, also marketed soapstone in sawed form as metalworker's crayons or blocks for carving. Canada's production of pyrophyllite was confined to Newfoundland where Newfoundland Minerals, Ltd., operated an open pit mine to provide material for use in the manufacture of ceramic tile. The greater part of the talc and soapstone was consumed in Canada, but all the output of pyrophyllite was exported.

Finland.—The only producer of the mineral in Finland, Suomen Talkki Oy., announced that in 1972, in order to meet increased demand from the paper industry and despite intensified competition in filler application from British kaolin, it had been obliged to step up its output of high-quality floated talc by one-fourth.

France.—A detailed description was published of the operations of what is probably the world's largest talc mine, that of S.A. des Talcs de Luzenac in the foothills of the French Pyrénées. The Luzenac quarry, at an exposed position on the side of Mount Soularac at 6,000 feet above sea level, can be operated only 6 months of the year but even so supplies nearly half of the annual talc production of the entire European continent.[5]

Greece.—A magazine article surveyed Greece's situation with regard to a number of nonmetallic minerals including talc.[6] Talc deposits are found on the Greek mainland near Larissa in Thessaly and near Thessaloniki in Macedonia, as well as on the islands of Crete and Tinos. The country's most active talc mines at present are those on Tinos, but production there has been sharply curtailed in recent years because of the increasing preference of Greek tile manufacturers for talc imported from Italy.

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[5] Ironman, R. Pyrenean Talc Deposit Yields 220,000 tpy. Rock Products, v. 76, No. 8, August 1973, pp. 72, 74.

[6] Industrial Minerals (London). Greece: A Wealth of Industrial Minerals. No. 75, December 1973, pp. 9–57.

Table 8.—Talc, soapstone, and pyrophyllite: World production, by country

(Short tons)

Country [1]	1971	1972	1973 [p]
North America:			
Canada (shipments)	65,562	80,946	110,000
Mexico	1,889	3,450	2,324
United States	1,037,297	1,107,404	1,246,534
South America:			
Argentina	[r] 54,881	40,827	[e] 44,000
Brazil (talc) [e]	143,000	143,000	143,000
Chile	1,938	2,021	1,938
Colombia	2,177	[e] 2,477	992
Paraguay	176	243	276
Peru	1,057	[e] 1,100	[e] 1,100
Uruguay (ground talc)	939	1,458	2,201
Europe:			
Austria	100,995	91,725	101,638
Finland	110,979	99,568	120,928
France	279,579	250,548	285,363
Germany, West (marketable)	32,692	34,743	[e] 33,000
Greece	2,045	[e] 2,200	[e] 2,200
Hungary	17,600	[e] 17,600	[e] 17,600
Italy (talc and steatite)	[r] 152,936	163,607	161,539
Norway (ground talc)	85,092	[e] [r] 85,000	[e] 85,000
Portugal	1,405	1,327	1,224
Romania [e]	[r] 63,000	[r] 63,000	66,000
Spain	44,911	44,000	[e] 44,000
Sweden	26,505	29,107	[e] 33,000
U.S.S.R. [e]	420,000	430,000	440,000
United Kingdom	13,228	17,637	[e] 18,000
Africa:			
Botswana	143	--	--
Egypt, Arab Republic of	6,968	8,518	[e] 8,500
South Africa, Republic of [2]	12,975	11,926	13,055
Swaziland (pyrophyllite)	225	119	139
Zambia	160	4,905	1,467
Asia:			
Burma	237	[e] 240	141
China, People's Republic of [e]	165,000	165,000	165,000
India	208,094	209,189	228,344
Japan [3]	1,731,827	1,661,114	1,723,540
Korea, North [e]	99,000	110,000	120,000
Korea, Republic of (talc and pyrophyllite)	234,185	259,867	348,257
Pakistan (soapstone)	[e] 5,200	4,846	4,390
Philippines	1,452	1,110	1,801
Taiwan (soapstone)	43,036	27,328	25,490
Thailand (pyrophyllite)	55	1,709	[e] 2,200
Oceania: Australia	[r] 52,774	61,891	[e] 62,000
Total	[r] 5,221,214	5,240,750	5,666,181

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition to the countries listed, Southern Rhodesia is believed to produce talc, but available information is inadequate to make estimates of output levels.

[2] Includes talc and wonderstone (pyrophyllite).

[3] Includes talc and pyrophyllite: in addition, pyrophyllite clay is produced as follows in short tons: 1971—354,160; 1972—343,180; 1973—355,096.

TECHNOLOGY

Research papers were published presenting information on properties that may be of assistance in delineating the genetic relationships of the mineral talc and hence possibly also in guiding future exploration in quest of commercial deposits. Scientists at Johns Hopkins University, in studying the stability field of talc at the earth's surface to define the conditions under which the mineral might be expected to form, concluded that the Gibbs free energy of the talc molecule, $Mg_3Si_4O_{10}(OH)_2$, must be at least 3 to 5 kilocalories per mole less negative than the previously accepted value. The new figure arrived at was —1,320 $\pm$ 2 kilocalories, a value said to be consistent with observed natural occurrences of talc.[7]

A British soil laboratory team determined the crystallographic properties of talc, the pure mineral, by a photographic X-ray diffraction procedure supplemented by least-squares mathematical analysis and

[7] Bricker, O. P., H. W. Nesbitt, and W. D. Gunter. The Stability of Talc. Am. Minerologist, v. 58, Nos. 1–2, January–February 1973, pp. 64–72.

reported that the true crystal form is triclinic and not monoclinic as is stated in many texts.[8]

The British investigators, confirming the conclusion drawn by a collaboration of workers in the United States several years ago,[9] reported that "The layers of the structure have almost monoclinic symmetry but the nearly hexagonal rings of oxygen atoms on the surfaces of the layers, formed by the bases of the silica tetrahedra, are not held in register by interlayer ions as they are in micas but are partly displaced so that the stack of layers forms a triclinic crystal."

Coincidentally, a lecture given at the annual meeting of the American Ceramic Society, Cincinnati, Ohio, April 30, 1973, included the following statement in regard to another of the talc-group minerals: "Until recently, pyrophyllite was regarded as a two-layer monoclinic structure, but in the course of studying the dehydroxylation reaction of this mineral it became necessary to reconsider the accepted structure. After a search for well-crystallized material, which is not easily obtained in the case of pyrophyllite, the structure was found to be a one-layer triclinic form."[10]

Exploration of a whole new technological frontier, in which synthesis of diamond has already been achieved and production of superconducting metallic hydrogen looms as a definite possibility for the near future, was the subject of a published essay.[11] Advances in this field of investigation, which involves subjecting materials simultaneously to temperatures measured in thousands of degrees and pressures in millions of pounds per square inch, demand the development of increasingly ingenious and sophisticated techniques for bringing forces of such unprecedented magnitudes to an effective focus. Several of the types of apparatus devised for these researches take advantage of the pressure transfer characteristics of pyrophyllite.

An article in an industrial journal compared the properties and mineralogical compositions of platy talcs originating in Montana and California with those of the so-called fibrous variety mined in the East (probably New York), explaining on that basis the results observed when substituting western mineral for eastern in established paint formulation practices.[12] It was concluded that utilization of a pure, platy talc to replace the more mineralogically heterogeneous type of material previously used can be accomplished without difficulty by observing two fundamental rules of paint compounding technology: (1) adjustment of paint PVC (pigments volume concentration) to compensate for differences in the absorptivity and void volume of the pigmentation, that is to say in the CPVC (critical pigment volume concentration), and (2) paying particular attention to the wetting/dispersing/stabilizing ingredients in the paint formula. It was further stated that, if these precautions are taken, no more than minor changes in paint properties, mostly arising from particle shape differences, need be anticipated. Appended to the article was a derivation of mathematical expressions for use in calculating numerical values for PVC and CPVC.

Toilet and pharmaceutical preparations, especially cosmetics ("talcum powder") constitute the end uses most familiarly associated with the mineral talc, although the tonnages currently consumed in this way account for no more than a minor fraction of each year's total. In value terms, the commercial significance of these applications is far from minor, however, because only substances of exceptional quality and outstanding purity and biological integrity, which are hence the highest priced, can meet the exacting specifications involved. An updated version was published of what has come to be accepted as the most authoritative treatise available on the technology of the compounding and testing of cosmetics. An extensive review of the new edition appeared in a scientific magazine.[13]

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[8] Rayner, J. H., and G. Brown. The Crystal Structure of Talc. Clays and Clay Miner, v. 21, No. 2, April 1973, pp. 103–114.

[9] Ross, M., W. L. Smith, and W. H. Ashton. Triclinic Talc and Associated Amphiboles from Gouverneur Mining District, New York. Am. Minerologist, v. 53, Nos. 5–6, May–June 1968, pp. 751–769.

[10] Brindley, G. W. The World of Clays and Clay Minerals. Am. Ceram. Soc. Bull., v. 52, No. 12, December 1973, pp. 892–895.

[11] Spain, I. L., and K. Ishizaki. Materials Under Pressure. Chemtech, v. 3, No. 6, June 1973, pp. 367–378.

[12] Todd, B. H. Substitution of Montana Platy Talc for Fibrous Eastern Talcs in Paint Formulations. Am. Paint J., v. 57, No. 55, July 2, 1973, pp. 44–47, 53–57.

[13] Harry, R. G. Harry's Cosmeticology, formerly The Principles and Practice of Modern Cosmetics (revised by J. B. Wilkinson, in cooperation with P. Alexander, E. Green, B. A. Scott, and D. L. Wedderburn). Chemical Publishing Co., Inc., New York. Rev. by P. Morrison, Sci. Am., v. 229, No. 4, October 1973, pp. 127–128.

Success in studies aimed at elucidation of possible physiological consequences from absorption of talc into body tissues, whether by routes of ingestion, inhalation, or simple surface contact, hinges on an unequivocal means of identifying and measuring exceedingly minute quantities of the mineral profusely diluted with substances likely to interfere with and obscure the analysis. A British biological research organization developed a procedure for achieving a controlled partial dehydration of pure mineral talc and then replacing the expelled water, H_2O, with an equivalent quantity of tritium oxide, T_2O. It was thought that the presence of the radioactive hydrogen isotope "tag" would then provide an exceptionally sensitive tool for locating, identifying, and quantitatively estimating the tritiated talc after it had become dispersed within a living organism. Work was continued toward application of the new technique in the investigation of suspected cases of talc-induced pathology.[14]

[14] Gangolli, S. D., R. F. Crampton, and A. G. Lloyd. Preparation of Tritium-Labelled Talc. Nature (London), v. 242, No. 5393, Mar. 9, 1973, p. 113.

Thorium

By Roman V. Sondermayer [1]

During 1973 primary thorium supplies from two domestic mines, located in Georgia and Florida, and imports, mostly from Malaysia, were more than adequate to meet demand. As in the past, there was no direct mine production of thorium. Monazite, the principal source of thorium, continued to be a byproduct of titanium mining and was recovered for its rare-earth content. Because of low thorium demand, thorium-containing residues from these operations were stored in holding areas for future use. However, during 1973 far lesser quantities of thorium-bearing materials were sent to holding areas than in the past. This change resulted from partial replacement of monazite by other materials as the major source of rare-earth oxides.

The weak market continued throughout 1973, but long-range potential for use of thorium was considered good. Energy shortages throughout the industrialized countries stimulated a search for new sources of energy. The existence of large resources of thorium in the United States and in the world encouraged research on the use of thorium as a nuclear fuel and on thorium-fueled reactors. Thorium programs sponsored by the Atomic Energy Commission (AEC) were under review, and more intensive research programs were expected. In contrast to higher demand for thorium as a nuclear fuel, only slight increases in demand were registered for other, nonenergy applications of thorium.

During 1973 thorium highlights were related to research and to industrial activities. Research started on application of the high-temperature, gas-cooled reactor (HTGR) as a source of industrial heat in production of hydrogen in coal gasification. A new process for utilizing U_{233} from domestic thorium in light-water-reactors (LWR) was announced. Seven HTGR's with a total capacity of 5,730 megawatts electrical (Mwe) were on order at the end of 1973. One HTGR, at the Fort St. Vrain, Colo., powerplant, with a capacity of 330 Mwe, was scheduled for commercial operation in 1974. In the last quarter, Gulf Oil Corp. and the Royal Dutch-Shell group entered into two 50–50 partnerships. The first, under the name General Atomic Co., will conduct operations in the United States. The second, under the name General Atomic International, will operate elsewhere. Shell companies initially contributed around $200 million to the partnership and further cash requirements will be provided equally by the partners. The partnership will be engaged primarily in developing, manufacturing, and marketing HTGR's.

One of the two processors of monazite for thorium stopped production at yearend.

DOMESTIC PRODUCTION

Mine Production.—Two mines, one in Georgia and the other in Florida, were the only producers of thorium in the country. At Humphreys Mining Co., with its operation near Folkston, Ga., output was slightly lower in 1973. The estimated ThO_2 content of monazite was 4%. Mining for titanium and zirconium was the principal activity at Folkston, and recovery of monazite was a byproduct operation. Suction dredges were used to mine the heavy beach sands. Most of the monazite was sold to W. R. Grace & Co., Chattanooga, Tenn. Ore reserves at the present mining site were expected to be exhausted by mid-1974. The company planned to continue operations by developing another heavy mineral sand deposit in Florida, a few miles south of the Folkston deposit. The heavy mineral sand concentrates from this new deposit will be proc-

[1] Physical scientist, Division of Nonferrous Metals—Mineral Supply.

essed at the existing plant near Folkston. Humphreys Mining Co. continued land rehabilitation of the area disturbed by mining. Mill waste was used as fill and, after grading, top soil was respread, and planted with grass.

Titanium Enterprises, jointly owned by American Cyanamid Co. and Union Camp Corp., was the second domestic monazite producer. At this operation, located near Green Cove Springs, Fla., the company mined a Pleistocene beach sand deposit mostly for ilmenite, rutile, and zircon. As in Georgia, monazite was a byproduct, and suction dredges were the principal mining equipment. During the latter part of the year, production of monazite was lower than mine capacity. Shortages of energy slowed the operation.

Refinery Production.—During 1973 the principal domestic firms processing monazite for thorium were W. R. Grace & Co., Davison Chemical Division, at Chattanooga, Tenn., and Lindsay Rare Earths, affiliated with Kerr-McGee Chemical Corp., West Chicago, Ill. The Lindsay plant stopped operations at yearend because of increased production costs.

A number of thorium-processing companies and dealers maintain stocks of various compounds and of the metal for nonenergy use and for nuclear fuels. Table 1 shows the principal companies.

Table 1.—Companies processing and fabricating thorium, in 1973

Company	Plant location	Operations and products
American Light Alloys, Inc	Little Falls, N.J	Magnesium-thorium alloy.
Consolidated Aluminum Corp	Madison, Ill	Do.
Controlled Castings Corp	Plainview, N.Y	Do.
Gallard-Schlesinger Chemical Manufacturing Corp.	Carle Place, N.Y	Processes oxide, fluoride, and metal.
General Electric Co	San Jose, Calif	Nuclear fuels.
Do	Wilmington, N.C	Do.
W. R. Grace & Co	Chattanooga, Tenn	Processes domestic and imported monazite; produces oxide; stocks of hydroxide and metal powder.
Gulf General Atomic Co	San Diego, Calif	Nuclear fuels.
Gulf United Nuclear Fuels Corp	Hematite, Mo	Do.
Do	New Haven, Conn	Do.
Hitchcock Industries, Inc	South Bloomington, Minn	Magnesium-thorium alloys.
Kerr-McGee Chemical Corp	Cimarron, Okla	Nuclear fuels.
Lindsay Rare Earths	West Chicago, Ill	Processes imported monazite; stocks of thorite; produces oxide, nitrate, and oxalate.
N L Industries, Inc	Albany, N.Y	Nuclear fuels.
Nuclear Chemicals and Metals Corp.	Huntsville, Tenn	Do.
Nuclear Fuel Services, Inc	Erwin, Tenn	Do.
Nuclear Materials & Equipment Corp. (NUMEC).	Apollo, Pa	Do.
Do	Leechburg, Pa	Do.
Ventron Corporation, Chemicals Div.	Beverly, Mass	Metallic thorium.
Wellman Dynamics Corp	Creston, Iowa	Magnesium-thorium alloy.
Westinghouse Electric Corp	Bloomfield, N.J	Processes compounds; produces metallic thorium.
Do	Columbia, S.C	Nuclear fuels.

CONSUMPTION AND USES

In 1973 the estimated apparent consumption of monazite and thorium compounds was about 240 tons of ThO_2 equivalent. This estimate was based on domestic mine production, imports, and changes in domestic stocks of monazite and thorium compounds. Actual industrial demand was substantially lower; the available monazite supply was processed essentially for its rare-earth content and most of the thorium-containing residues entered company holding areas. Nonenergy and energy uses were the two major areas of thorium consumption. Based on sales from Government stocks, and shipments from processors, U.S. industrial demand was estimated at about 130 tons of ThO_2 equivalent. Of the total, some 100 tons of ThO_2 were consumed in nonenergy sectors of the economy. Principal applications were in Welsbach incandescent gaslight mantles, as a hardener for magnesium-thorium alloys, in dispersion hardening, refractories, electronics, and chemical (catalytic) applications. About 30 tons of ThO_2 equivalent were used for production of nuclear fuels and nuclear research. Table 2 shows the status of HTGR development in the United States.

Philadelphia Electric Co. announced that two 1,160 Mwe HTGR's will be located in Fulton Township, Lancaster County, about 9 miles north of the Conowingo Dam and on the east side of the Susquehanna River. Each of the two reactors will be connected to two Westinghouse turbine generators.[2]

Gulf General Atomic (GGA) has chosen Bechtel Corp. of San Francisco, Calif., to design the plant for a 300-Mwe demonstration gas-cooled fast breeder reactor (GCBR). The cost for balance-of-plant design will be paid for with GGA and utility funds. The work will be coordinated by the Power Technology groups of Bechtel's Scientific Development Division. The GCBR is based on HTGR technology, and fuel and physics technology of the liquid metal fast breeder reactor.[3]

STOCKS

The Government stockpile, in the form of thorium nitrate, totaled 1,761 tons ThO_2 equivalent on January 1, 1974. During 1973 the thorium stockpile objective was reduced to zero, and all stockpiled thorium was available for disposal. However, only 28 tons of nitrate was sold from stockpile during the year.

Stocks held by industry were estimated in terms of ThO_2 equivalent, as follows: In monazite, 80 tons; in compounds, 82 tons; and in metal and alloys, 1 ton.

[2] American Nuclear Society. Philadelphia Electric Sites Its Two HTGR's. Nuclear News, v. 16, No. 10, August 1973, p. 45.
[3] American Nuclear Society. Gas-cooled Fast Breeder: Demo Design Moves Ahead. Nuclear News, v. 16, No. 10, August 1973, p. 43.

Table 2.—Status of HTGR development in the United States[1]

State	Station (plants)	Capacity (megawatts electrical)	Status	Scheduled start of commercial operation
California	Eastern: Desert 1	770	Construction permit application in preparation.	1981
Do	Eastern: Desert 2	770		1983
Colorado	Fort St. Vrain	330	Fuel loading started in October 1973.	1974
Delaware	Summit 1	770	Construction permit application in preparation.	1979
Do	Summit 2	770		1982
Pennsylvania	Peach Bottom 1	40	In operation.	1967
Do	Fulton 1	1,160	Construction permit application in preparation.	1981
Do	Fulton 2	1,160		1983
Total	8	5,770		

[1] At yearend 1973.

PRICES

During 1973 the price of monazite increased on the international market. The average declared value for imported monazite was $135 per ton compared with $99 in 1972.

Prices listed by the Davison Chemical Division, W. R. Grace & Co., Chattanooga, Tenn., were in the following ranges, per pound, depending on the quantity of purchase: Nitrate wire grade, 47% ThO_2, $2.45–$2.50; nitrate, mantle grade, 47% ThO_2, $2.50–$2.55; ThO_2, ceramic grade, 99.9% ThO_2, $6–$10; and ThO_2 refractory grade, 99.9% ThO_2, $7–$11.

Quotations in the American Metal Market on thorium metal in pellets remained steady at $15 per pound. The pure metal was $65 per pound.

FOREIGN TRADE

Imports of monazite, mainly for rare-earth content, increased above 1972 levels. Malaysia was the principal supplier. Imports of compounds declined, but imports of metal (scrap) increased. European countries and Canada were the main suppliers. Exports statistics for thorium compounds are combined with those for uranium in trade statistics. Although exact data are not available, thorium exports are believed to be minor.

Table 3.—U.S. foreign trade in thorium and thorium-bearing materials
(Quantity in pounds unless otherwise specified)

	1971		1972		1973		Principal sources and destinations, 1973
	Quantity	Value	Quantity	Value	Quantity	Value	
EXPORTS							
Ore and concentrate (ThO_2 content)	--	--	--	--	2,183	$13,724	All to Canada.
Metals and alloys [1]	65,592	$943,930	16,624	$291,048	14,737	269,708	Italy 12,071; Japan 1,910; Canada 654; West Germany 94; United Kingdom 8.
Compounds [1]	6,021,148	38,498,069	6,714,148	46,614,501	4,028,095	26,107,130	Canada, 3,788,776; United Kingdom 195,817; Japan 41,265; Indonesia 1,706; other 581.
IMPORTS							
Ore and concentrate:							
Monazite (short tons)	3,373	383,733	894	88,767	1,876	254,125	Malaysia 1,778; Thailand 98.
ThO_2 conent [e]	404,800	--	107,300	--	300,160	--	
Waste and scrap	--	--	15	285	20	280	All from Canada.
Compounds:							
Nitrate	1,100	1,891	4,502	15,612	2,200	3,104	All from France.
Oxide	2,481	8,692	317	1,833	1,603	5,811	France 1,600; West Germany 3.
Oxide equivalent, in gas mantles [e 2]	5,900	618,616	5,804	539,558	3,882	453,692	United Kingdom 2,115; Malta 633; Italy 457.
Other	227	28,195	151	22,811	177	32,754	Switzerland 138; United Kingdom 24; West Germany 15.

[e] Estimate.
[1] Includes uranium; thorium and uranium are undifferentiated in official statistics.
[2] Based on manufacture of 1,000 gas mantles per pound ThO_2.

WORLD REVIEW

Australia, India, Malaysia, Brazil, and the United States remained the principal thorium producers in the world. As in the United States, most thorium was a byproduct of rare-earth recovery from monazite. Because of the low demand for thorium, a sizable oversupply existed in world markets. Some of the producing countries regulated transactions in thorium metal and compounds because of their nuclear uses.

Australia.—A pilot plant for production of ilmenite and rutile, located 150 miles north of Perth and operated by Allied Eneabba Pty. Ltd., started operation in the spring of 1973. The new plant will also produce monazite, capacity for which was not disclosed.

Brazil.—The Commissão Nacional de Energia Nuclear (CNEN), a Brazilian Government agency, controlled the beach sand industry of Brazil. This industry remained the only producer of monazite in the country.

CNEN, through its Administração da Produção da Monazita (APM), operated workings at Itabapoana (Rio de Janiero) and Cumuruxatiba (Bahia). Monazita e Ilmenita do Brasil (MIBRA), a privately owned company, operated facilities for the production of monazite at Guarapari.

The mixed Government-private company, Cia. Brasileira de Tecnologia Nuclear (CBTN), took control of Orquima, a private company in the city of São Paulo. The new company, named Usina de Santo Amaro (USAM), was operating a pilot plant that separated rare-earth oxides and thorium from monazite. The aim was to develop an effective system for this separation and then market the rare earths and thorium independently. Formerly, USAM furnished only mixed concentrates.

Canada.—There was no official indication that thorium was produced in Canada during 1973. However, some thorium may have been produced because Denison Mines Ltd. reactivated its yttrium circuit at its Elliot Lake mill in Ontario. Production of yttrium requires removal of thorium during the process.

France.—An agreement was signed by GGA, the Commissariat à Énergie Atomique (CEA), and French industry to organize an HTGR nuclear-fuel manufacturing and marketing company. The new company, La Société de Combustible pour Reacteurs à Haute Température (CORHAT), will be jointly owned by GGA (30%) and a French organization, Cie. Industrielle de Combustibles Atomiques Frittes (70%). This agreement follows a previously signed agreement between GGA and CEA for exchange of HTGR technology.

Germany, West.—The Ministry of Science and Technology announced that reactor development funds, amounting to $80 million, will be used for the helium-turbine equipped 300-Mwe thorium high-temperature reactor (THTR) under construction at Schmehausen. Construction of this reactor was financed and supervised by Hochtemperatur-Reaktorbau GmbH (HRB), Cologne, West Germany. HRB belongs to the Swiss-controlled Brown, Boverie and Co. Mannheim (55%), and GGA (45%).

India.—Production of monazite decreased during fiscal years 1972 and 1973. The main reasons for the lower output were shortages of electric power and caustic soda, and leaner monazite content of beach sands. Production of thorium hydroxide (dry) was reported at 689 tons. Installed capacity for production of thorium hydroxide was 904 tons annually. Thorium-producing facilities of Indian Rare Earths Ltd. (IRE) were operating at about 76% of installed capacity. The Government of India bought all thorium hydroxide produced by IRE.

IRE continued to operate the thorium plant at Trombay as agent of the Government of India. Construction started on a solvent extraction pilot plant for production of thorium oxide and nitrate at Trombay.[4]

Beach sands of the coastlines of Kerala and Tamil Nadu remained India's most important commercial source of thorium in monazite. The largest concentrations occur at Chavara near Quilon in Kerala and at Manavalakurichi, a coastal village in the Kenyakumari District of Tamil Nadu. Large unmeasured tonnages of monazite also exist in sandstone beds inland from each of the black sand beach areas. Other beach sand areas exist around the southern tip of India and along the east coast of the country through Visakhapatnam to Palmiras Point, southwest of Calcutta. IRE continued as the

[4] Indian Rare Earths Ltd. 23rd Annual Report, 1972–73. Bombay, 1973, p. 23.

only mineral sand mining and processing firm in India. The company minerals division with offices at Quilon, Kerala, operated raw material plants at Manavalakurichi and at Chavara. Annual capacities for monazite at these two plants were reported at 4,898 and 645 tons, respectively. The average ThO_2 content of India monazite ranged from 8% to 10%.

India's nuclear planning remained oriented toward self-reliance. Having large resources of thorium, India decided to direct its future nuclear development toward thorium-fueled reactors. An experimental fast breeder reactor, located at Kalpakkam, near Madras, for which planning was underway, will be fitted with oxidal and radial thorium blankets. France has offered aid for construction of this reactor.

Japan.—The Public Utilities Bureau of the Ministry of International Trade and Industry proposed that the Electric Power Development Company (EPDC) should develop the HTGR in Japan. This would be the first reactor built by EPDC. The EPDC was established to develop hydroelectric power but later entered the field of thermal plants.

Japan pushed forward in expanding use of the HTGR. The Government and the iron and steel industry founded research on use of HTGR-generated process heat in production of steel.

The Japan Atomic Energy Research Institute completed a preliminary design for a multipurpose HTGR (power generation and process heat). Kawasaki Heavy Industries operated high-temperature piping in experimental production of iron and steel.

The Science and Technology Agency, established by the Government, released figures on quantities of nuclear fuel materials in Japan at the end of 1973. Stocks of thorium were reported at 565 tons in form of welding rods and lenses.

Table 4.—Monazite concentrate; World production by country

(Short tons)

Country [1]	1971	1972	1973 [p]
Australia	[r] 4,829	5,537	4,842
Brazil	1,502	2,453	1,606
India	[2] 4,664	4,504	3,858
Malaysia [3]	[r] 1,622	1,927	2,200
Mauritania [e]	110	110	110
Nigeria	102	11	6
Sri Lanka	7	[e] 10	[e] 10
Thailand	123	188	[e] 220
United States	W	W	W
Zaire	[r] 198	251	252
Total	[r] 13,157	14,991	13,104

[e] Estimate. [p] Preliminary. [r] Revised. W Withheld to avoid disclosing individual company confidential data.

[1] In addition to the countries listed, Indonesia and North Korea produce monazite, but information is inadequate to make reliable estimates of output levels.

[2] Year beginning April 1 of that stated.

[3] Exports.

WORLD RESOURCES

Noncommunist world resources of thorium were evaluated by the U.S. Geological Survey [5] as shown in Table 5.

[5] Staatz, Mortimer H., and Jerry C. Olson. Thorium, chapter in United States Mineral Resources. U.S. Geol. Survey Prof. Paper 820, 1973, pp. 468–476.

Table 5.—Noncommunist world resources of thorium [1]

(Thousand short tons)

State	Recoverable as byproduct or coproduct	Recoverable for grade of 0.1% ThO_2 or higher	Recoverable for grade less than 0.1% ThO_2
Australia	50	--	--
Brazil	150	14.0	--
Canada	580	--	--
Greenland	--	--	750
Rep. of South Africa	75	--	--
United States	46	106.5	142
Others	84	--	10

[1] Not shown, because of inadequate data, are resources of Argentina, Sri Lanka, Norway, Uruguay, the U.S.S.R., and several other countries.

TECHNOLOGY

During 1973, energy, process heat, metallurgical applications, and isotopes were the principal subjects of research studies related to thorium. Except for some energy-oriented projects, most of the research was basic. Estimates indicated that two-thirds of the thorium research was on energy applications.

Nonenergy.—Most nonenergy research was related to thorium alloys. Metallurgical research was directed toward determining the effect of thorium and thorium compounds on the physical and chemical properties of alloys in different environments. One study indicated that ThO_2 dispersion in platinum and gold gives unique properties to these metals. Detailed results were announced on platinum only. Stress-rupture properties of platinum, better than those of the best platinum-rhodium alloys, were obtained when ThO_2 was dispersed. Addition of ThO_2 helped improve strength and durability of the platinum-thorium alloy at elevated temperatures. The platinum-thorium alloys with high corrosion resistance may have applications in the aerospace, electrical and electronic, chemical, and glassmaking industries.[6]

Another result of metallurgical research showed that ThO_2 strengthens oxygen-free-high-conductivity (OFHC) copper when 0.3% to 3% ThO_2 is alloyed with OFHC copper. The Cu–ThO_2 alloy retained excellent electrical and thermal conductivity. Application may include use in structural and current-carrying parts of microwave tubes, high-temperature conductors, and die-casing parts.[7]

A recent investigation was conducted to develop powder preparation and processing methods which could improve the optical perfection of sintered Y_2O_3 containing various quantities of ThO_2 and Nd_2O_3 in solid solution. The major part of the investigation was related to optical defects in the sintered material. A new process produced powders with a composition of 89% Y_2O_3, 10% ThO_2, and 1% Nd_2O_3 suitable for a sintering approach.[8]

Y_2O_3-ThO_2 ceramics find use as solid electrolytes. Y_2O_3-ThO_2 and zirconia are electrical insulators but, at elevated temperatures, they become electrical conductors. The high-temperature conductivity can be controlled by the amount of stabilizers (CaO and Y_2O_3) used in the formation. Characteristics of Y_2O_3-ThO_2 ceramics makes them suitable for new approaches to oxygen measurement, hydrogen production, and nuclear reactors. The Y_2O_3-ThO_2 ceramics are highly resistant to attack by molten sodium. Research was underway to use Y_2O_3-ThO_2 electrolytes for sodium-cooled nuclear reactors.[9]

Energy.—Energy research was directed mostly toward development of thorium fuels and their use in reactors. The AEC sponsored research and development in the nuclear field. In addition, GGA conducted research on applications of the HTGR gas-cooled breeder reactor (GCBR) and on a symbiotic relation in use of fuel between the GCBR and the HTGR.

Possibilities for the use of the HTGR as a source of process heat in various industrial fields were examined during 1973. For this use, the reactor remains basically identical to the HTGR used for power generation except for some modification required for generation of heat in the reactor and for application of that heat.

GGA and Stone & Webster Engineering (S&W), a subsidiary of Stone & Webster, Inc., started research on the use of nuclear power for converting coal into pipeline-with the HTGR. The S&W process treats coal as a basic hydrocarbon in which the hydrogen content is increased from approximately 5% in raw material to 25% in the methane product. The process quality gas and clean liquid fuels. The program integrated the S&W gasification process involved a stepwise hydrogenation of coal, first to liquid and then to synthetic gas by hydrogasification. The HTGR is included for power production of large quantities of hydrogen that are essential to the process. S&W will be the project manager of a 2-year test program that will cost approximately $650,000.

There are important advantages in the

[6] American Metal Market. Thoria Added to Platinum, Gold Gives Unique Results. V. 80, No. 215, Nov. 6, 1973, p. 26.

[7] Materials Engineering. Material Outlook, Metals. V. 77, No. 1, January 1973, p. 10.

[8] Gereskovich, C., and K. N. Woods. Fabrication of Transparent ThO_2-Doped Y_2O_3. Am. Ceramic Soc. Bull., v. 52, No. 5, May 1973, pp. 473–478.

[9] Sproule, T. Richard. Zirconia and Yttria-Thoria Ceramics Find New Uses As Solid Electrolytes. Mater. Eng., v. 19, No. 1, January 1974, p. 40.

use of a nuclear heat source in the process. The combined process produces about 30% more clean fuel per unit of coal fed through systems using coal for both a source of process heat and feedstock. In addition, HTGR-produced heat reduces the price sensitivity of synthetic gas to changes in the price of coal. Research was expected to take about 3 years. Construction of the commercial plant would take about 5 years after receiving all necessary approvals.

Research on production of hydrogen from water has been conducted by GGA with the HTGR heat source. A new multistep thermochemical process, using heat and chemicals, decomposed water into hydrogen and oxygen. The temperature range of 1,500° to 1,800° F, far lower than expected, is within the HTGR temperature range. Chemicals used in the process can be reprocessed, and only heat and water were consumed.[10]

The idea of a symbiotic relation between the GCBR and the HTGR was announced during 1973. Such a relation leads to an advantage in fuel cycle economics. The GCBR can supply fissile feed materials that are the best fuel for the HTGR. Uranium-233, bred in thorium blankets around the GCBR cores, could supplement the recycled supply of this material in the HTGR's fuel feed. One GCBR could supply fissile materials for three HTGR's.

Pacific Nuclear, Inc., in Richland, Wash., has announced development of a new process for utilizing U_{233}, (converted from Th_{232} in the HTGR) in existing LWR's. The new process prevents formation of undesirable U_{232} whose daughter products emit gamma radiation. This prevention is accomplished by a new core-loading pattern.[11]

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[10] American Nuclear Society. Production of Hydrogen Aim of the GGA Program. Nuclear News, v. 16, No. 15, December 1973, p. 79.

[11] American Nuclear Society. Process Devised to Burn Th-U-233 in Existing LWR's. Nuclear Industry, v. 20, No. 11, November 1973, p. 48.

Tin

By Keith L. Harris [1]

The Free World supply of tin trended from oversupply at the beginning of the year to undersupply at yearend with a shortfall of about 23,000 long tons.[2] Combined General Services Administration (GSA) shipments and International Tin Council (ITC) buffer stock sales of over 21,000 tons failed to alleviate the tight supply conditions. Prices rose to record levels on the world markets.

World mine production of tin in 1973 was 232,404 tons, down 3% from the 1972 level. U.S. consumption of primary and secondary tin increased 8% for the year, the first increase in U.S. consumption since 1968. The major uses for tin were in solder, 33%; tinplate, 28%; bronze and brass, 13%; chemicals including tin oxide, 6%; and babbitt, 5%. Most of the Nation's tin, in the form of slabs, bars, and ingots, came from Malaysia and Thailand. Less than 100 tons of tin, from mines in Alaska, Colorado, and New Mexico, was mined domestically during the year. About one-fifth of the tin used in the United States in 1973 was reclaimed from scrap at about 85 secondary smelters.

Table 1.–Salient tin statistics

(Long tons)

	1969	1970	1971	1972	1973
United States:					
Production:					
Mine	W	W	W	W	W
Smelter	345	NA	4,000	r 4,300	4,500
Secondary	22,775	20,001	20,096	20,180	20,477
Exports (including reexports)	2,903	4,452	2,262	1,134	3,406
Imports for consumption:					
Metal	54,950	50,554	46,940	52,451	45,845
Ore (tin content)	--	4,667	3,060	4,216	4,480
Consumption:					
Primary	57,730	52,957	51,980	r 53,501	58,142
Secondary	23,060	20,880	17,970	r 15,700	16,498
Price: Straits tin, in New York, average cents per pound	164.435	174.135	167.344	177.469	227.558
World production:					
Mine	225,725	228,500	r 231,401	r 239,610	232,404
Smelter	225,290	223,696	r 232,017	r 236,473	227,251

r Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data.

The only primary tin smelter-refinery operating in the United States in 1973 was the Texas City, Tex., facility of Gulf Chemical and Metallurgical Corp. (GCMC). The major feed to the smelter was tin concentrate from Bolivia's state-owned Corporación Minera de Bolivia (COMIBOL).

The Office of Preparedness (OP) lowered the tin stockpile objective from 232,000 tons to 40,500 tons during the year. GSA sold 19,262 tons of tin from the stockpile through commercial channels.

The average New York price for prompt delivery Straits (Malaysian) tin in 1973 was 227.558 cents per pound, a significant increase from the 1972 average of 177.469 cents per pound.

[1] Physical scientist, Division of Nonferrous Metals—Mineral Supply.
[2] Unless otherwise specified all units are long tons of contained tin.

The ITC invoked export controls on member producer nations from mid-January through September. At its September meetings, the ITC revised upwards the floor and ceiling prices of tin by 9% and 6%, respectively.

Legislation and Government Programs.—In April, the OP announced a reduction in the stockpile objective from 232,000 tons to 40,500 tons. A bill was submitted to Congress for authorization to dispose of the excess tin, but by yearend no action had been taken.

On June 7, GSA resumed commercial sales, suspended since July 1, 1968, of 18,253 tons of tin previously authorized for release. A disposal plan formulated by GSA, the Department of State, and the ITC proposed sales of 6,500 tons during the year, with 1,500 tons available through June and 5,000 tons available for the last half of the year. Demand for tin was so strong in July that the 5,000 tons allocated for the last half of the year was sold by July 11. In August, GSA discovered that an additional 32,000 tons could be released because the original authorization was not repealed in 1969 when Congress raised the objective to 232,000 tons. GSA resumed daily sales in September. A long-term sales program was announced December 5. Sales for the year total 19,262 tons, and shipments totaled 10,144 tons. At yearend, there was an excess of 190,512 tons on hand, of which 31,012 tons was approved for sale.

The Office of Minerals Exploration (OME), U.S. Geological Survey, continued its program of offering participatory loans for tin exploration up to 75% of approved costs.

DOMESTIC PRODUCTION

PRIMARY TIN

Mine Production.—Domestic production of tin in 1973 was less than 100 tons. Most of the year's output came from Colorado as a byproduct of molybdenum mining. Some tin concentrate was produced at dredging operations in Alaska and placer operations in New Mexico. Climax Molybdenum Co., a division of American Metal Climax Inc., announced it began preparation for open pit mining at its Climax mine in Colorado. This was in addition to a recently completed underground mining level. Climax recovered about 2 to 3 ounces of tin concentrate from each ton of ore processed. Getman Tin, Inc., began a small tin placer mining operation at Beaverhead, Catron County, N. Mex., in June. The Lost River Mining Corp. continued exploration at its property in the Lost River area of Alaska's Seward Peninsula. Financial arrangements were being negotiated for a $50 million facility to process 4,000 tons of ore per day from an open pit mine.

Smelter Production.—The only tin smelter in the United States is the Texas City, Tex., facility of GCMC. In 1973, it received 4,464 tons of tin-in-concentrate from Bolivia and 16 tons of tin-in-concentrate from the Republic of South Africa, which formed the base load, together with domestic tin concentrate and secondary tin-bearing materials. With the liquidation of the United Kingdom's Williams, Harvey & Co., Ltd. smelter, GCMC's major competitor for Bolivian concentrate, GCMC initiated plans to boost production from the present level of 4,500 tons per year to 8,000 tons per year by the end of 1974. Accordingly, GCMC and Bolivia negotiated a 10-year contract in which Bolivia guaranteed to deliver 6,000 tons of concentrate to GCMC in each of the first 3 years of the contract. Details of the remaining 7 years of the contract were not available. GCMC also had its GCMC brand of pig tin approved for delivery on the London Metal Exchange (LME).

SECONDARY TIN

The United States is the world's leader in the production of recycled, or secondary, tin. The United Kingdom, the Federal Republic of Germany, Austria, and Australia also produce secondary tin in significant quantities.

Of the tin recycled during 1973, 91% was an alloy constituent of bronzes, brasses, solders, and bearing and type metals. A small amount also remained in chemical compounds. Only 9% of the recycled tin, mostly from new tinplate scrap, found its way to market as metal. This latter volume provided only 3% of the total tin supplied to U.S. consumers in 1973, a proportion which does not vary appreciably from year to year.

Secondary tin furnishes about 25% of the total U.S. tin supply each year. In 1973 secondary tin produced in the United States increased 1% over the 1972 level to 20,477 tons.

Five companies in 11 States were engaged in the detinning business in 1973. Normally the raw materials used are tinplate scrap and spent chemicals or tinning solutions.

Table 2.—Secondary tin recovered from scrap processed at detinning plants in the United States

	1972	1973
Tinplate scrap treated ----long tons--	714,960	764,158
Tin recovered in the form of—		
Metal ----do----	1,494	1,416
Compounds (tin content) ----do----	672	677
Total [1] ----do----	2,166	2,093
Weight of tin compounds produced ----do----	1,284	1,450
Average quantity of tin recovered per long ton of tinplate scrap used pounds--	6.79	6.13
Average delivered cost of tinplate scrap ----per long ton--	$30.15	$48.90

[1] Recovery from tinplate scrap treated only. In addition, detinners recovered 371 long tons (551 tons in 1972) of tin as metal and in compounds from tin-base scrap and residues in 1973.

Table 3.—Tin recovered from scrap processed in the United States, by form of recovery

(Long tons)

Form of recovery	1972	1973
Tin metal:		
At detinning plants ----	2,001	1,737
At other plants --------	198	275
Total ----	2,199	2,012
Bronze and brass:		
From copper-base scrap--	9,281	9,428
From lead and tin-base scrap ----	73	59
Total ----	9,354	9,487
Solder ----	5,213	5,488
Type metal ----	1,232	1,052
Babbitt ----	854	751
Antimonial lead ----	604	948
Chemical compounds ----	716	727
Miscellaneous [1] ----	8	12
Total ----	8,627	8,978
Grand total ----	20,180	20,477
Value (thousands) ----	$80,222	$104,377

[1] Includes foil, cable lead, and terne metal.

Table 4.—Shipments of metal cans[1]

(Thousand base boxes[2])

Type of can	1972	1973 p	1973 change (percent)
FOOD AND BEVERAGES			
Fruit and fruit juices	13,639	14,526	+6.5
Vegetables and vegetable juices	21,755	23,914	+9.9
Milk, evaporated and condensed	2,404	2,245	−6.6
Other dairy products	379	298	−21.4
Soft drinks	31,485	36,049	+14.5
Beer	44,949	48,438	+7.8
Meat and poultry	3,683	3,681	−.1
Fish and other seafoods	3,185	3,018	−5.2
Coffee	3,595	3,713	+3.3
Lard and shortening	1,688	1,790	+6.0
Baby foods	1,460	1,345	−7.9
Pet foods	6,694	7,121	+6.4
All other foods, including soups	14,078	14,280	+1.4
Total	148,994	160,418	+7.7
NONFOOD			
Oils	3,095	2,726	−11.9
Paint and varnish	5,588	5,432	−2.8
Antifreeze	566	303	−46.5
Pressure packing (valve type)	5,877	6,007	+2.2
All other nonfood	6,552	5,381	−17.9
Total	21,678	19,849	−8.4
Grand total	170,672	180,267	+5.6
BY METAL			
Steel base boxes[2]	141,228	146,625	+3.8
Short tons (thousand)	5,582	5,792	+3.8
Aluminum base boxes	29,444	33,642	+14.2

p Preliminary.
[1] Includes tinplate and aluminum cans.
[2] The base box, a unit commonly used in the tinplate industry, equals 31,360 square inches of plate or 62,720 square inches of total surface area.
Source: U.S. Department of Commerce.

Table 5.—Stocks, receipts, and consumption of new and old scrap and tin recovered in the United States in 1973

(Long tons)

Type of scrap and class of consumer	Gross weight of scrap: Stocks Jan. 1	Receipts	Consumption: New	Consumption: Old	Consumption: Total	Stocks Dec. 31	Tin recovered: New	Tin recovered: Old	Tin recovered: Total
Copper-base scrap:									
Secondary smelters:									
Auto radiators (unsweated)	2,621	52,606	--	51,982	51,982	3,245	--	2,236	2,236
Brass, composition or red	3,438	70,738	16,672	54,015	70,687	3,489	901	2,010	2,911
Brass, low (silicon bronze)	603	2,683	2,271	728	2,999	288	--	5	5
Brass, yellow	4,655	54,125	6,569	47,441	54,010	4,770	24	480	504
Bronze	1,946	25,035	4,304	20,825	25,129	1,852	336	1,635	1,971
Low-grade scrap and residues	8,061	56,406	44,008	8,828	52,836	11,631	25	--	25
Nickel silver	570	4,165	520	3,660	4,180	555	4	28	32
Railroad-car boxes	316	2,183	--	2,138	2,138	361	--	102	102
Total	22,210	267,941	74,344	189,617	263,961	26,191	1,290	6,496	7,786
Brass mills:[1]									
Brass, low (silicon bronze)	5,838	20,724	22,603	--	22,603	3,959	--	--	--
Brass, yellow	15,154	307,229	303,670	--	303,670	18,713	223	--	223
Bronze	654	5,026	4,904	--	4,904	776	221	--	221
Nickel silver	4,990	23,515	25,186	--	25,186	3,319	--	--	--
Total	26,636	356,494	356,363	--	356,363	26,767	444	--	444
Foundries and other plants:[2]									
Auto radiators (unsweated)	882	9,927	--	9,396	9,396	1,413	--	422	422
Brass, composition or red	951	4,684	2,366	2,565	4,931	704	113	121	234
Brass, low (silicon bronze)	25	687	288	377	665	47	--	6	6
Brass, yellow	583	4,273	2,034	2,229	4,263	593	1	20	21
Bronze	175	783	155	683	838	120	12	52	64
Low-grade scrap and residues	173	900	205	497	702	371	--	--	--
Nickel silver	3	3	--	5	5	1	--	--	--
Railroad-car boxes	827	5,602	--	6,279	6,279	150	--	298	298
Total	3,619	26,859	5,048	22,031	27,079	3,399	126	919	1,045
Total tin from copper-base scrap	XX	XX	XX	XX	XX	XX	1,860	7,415	9,275
Lead-base scrap: Smelters, refiners, and others:									
Babbitt	285	12,400	--	12,084	12,084	601	--	586	586
Battery lead plates	35,089	499,431	--	486,105	486,105	48,415	--	514	514
Drosses and residues	r 16,980	140,771	138,109	--	138,109	19,642	2,896	--	2,896
Solder and tinny lead	405	11,364	--	10,706	10,706	1,063	--	1,662	1,662
Type metal	2,135	24,791	--	24,955	24,955	1,971	--	1,186	1,186
Total	r 54,894	688,757	138,109	533,850	671,959	71,692	2,896	3,948	6,844
Tin-base scrap: Smelters, refiners, and others:									
Babbitt	32	175	--	179	179	28	--	149	149
Block-tin pipe	15	179	--	163	163	31	--	162	162
Drosses and residues	735	2,588	3,094	--	3,094	229	1,571	--	1,571
Pewter	--	16	--	14	14	2	--	12	12
Total	782	2,958	3,094	356	3,450	290	1,571	323	1,894
Tinplate and other scrap: Detinning plants	--	--	764,158	--	764,158	--	2,464	--	2,464
Grand total	XX	XX	XX	XX	XX	XX	8,791	11,686	20,477

r Revised. XX Not applicable.
[1] Brass-mill stocks include home scrap, and purchased-scrap consumption is assumed equal to receipts; therefore, lines and total in brass-mill section do not balance.
[2] Omits "machine-shop scrap."

CONSUMPTION

The downward trend in tin consumption evident since 1968 was reversed in 1973. Total consumption of tin metal increased 8%, with primary and secondary tin consumption increasing 9% and 5%, respectively. The marked increase in tin used in solder, up 13% over the 1972 level, accounted for the majority of the overall rise. Although delegated to second place in relative importance of total tin consumption, tinplate continued as the most important primary tin consuming sector (37%). Consumption of tin for tinplate increased 1%, although the average amount of tin per short ton of tinplate continued to decline. An average of 9.7 pounds of tin was used per short ton of tinplate compared with 10.0 pounds in 1972. Most of the increased tinplate production was used in the manufacture of cans. Consumption increased in all sectors except bar tin and type metal. U.S. brass mills consumed 1,045 tons of primary tin, compared with 1,426 tons in 1972. Consumption of secondary tin, at 501 tons, was the same as in 1972.

Table 6.—Consumption of primary and secondary tin in the United States

(Long tons)

	1969	1970	1971	1972 r	1973
Stocks Jan. 1 [1]	28,152	23,441	21,165	18,557	18,490
Net receipts during year:					
Primary	55,125	52,096	51,727	55,074	59,164
Secondary	2,325	2,502	2,491	2,797	4,034
Scrap	21,624	19,748	16,179	13,892	13,713
Total receipts	79,074	74,346	70,397	71,763	76,911
Total available	107,226	97,787	91,562	90,320	95,401
Tin consumed in manufactured products:					
Primary	57,730	52,957	51,980	53,501	58,142
Secondary	23,060	20,880	17,970	15,700	16,498
Total	80,790	73,837	69,950	69,201	74,640
Intercompany transactions in scrap	2,995	2,785	3,055	2,629	2,504
Total processed	83,785	76,622	73,005	71,830	77,144
Stocks Dec. 31 (total available less total processed)	23,441	21,165	18,557	18,490	18,257

r Revised.
[1] Stocks shown exclude tin in transit or in other warehouses on Jan. 1, as follows: 1969—1,185 tons; 1970—80 tons; 1971—10 tons; 1972—140 tons; and 1973—970 tons.

Table 7.—Tin content of tinplate produced in the United States

Year	Tinplate waste—waste, strips, cobbles, etc., gross weight (short tons)	Tinplate (all forms) Gross weight (short tons)	Tinplate (all forms) Tin content [1] (long tons)	Tinplate (all forms) Tin per short ton of plate (pounds)
1969	581,594	5,944,758	26,886	10.1
1970	625,998	5,590,038	25,127	10.1
1971	547,959	5,297,970	23,669	10.0
1972	501,996	4,706,491	21,070	10.0
1973	522,043	4,908,347	21,267	9.7

[1] Includes small tonnage of secondary tin and tin acquired in chemicals.

Table 8.—Consumption of tin in the United States, by finished product

(Long tons of contained tin)

	1972			1973		
	Primary	Secondary	Total	Primary	Secondary	Total
Alloys (miscellaneous)	468	441	909	799	279	1,078
Babbitt	r 2,213	r 922	r 3,135	2,524	951	3,475
Bar tin	780	116	896	705	W	705
Bronze and brass	r 3,137	r 6,585	r 9,722	3,506	6,470	9,976
Chemicals including tin oxide	2,462	1,568	4,030	2,852	1,976	4,828
Collapsible tubes and foil	790	16	806	1,001	1	1,002
Solder	r 16,913	r 5,048	r 21,961	18,775	5,952	24,727
Terne metal	192	r 45	r 237	315	55	370
Tinning	r 2,461	79	r 2,540	2,541	44	2,585
Tinplate [1]	21,070	--	21,070	21,267	--	21,267
Tin powder	1,150	--	1,150	1,459	W	1,459
Type metal	103	737	840	80	560	640
White metal [2]	1,579	138	1,717	2,000	103	2,103
Other	183	5	188	318	107	425
Total	r 53,501	r 15,700	r 69,201	58,142	16,498	74,640

r Revised. W Withheld to avoid disclosing individual company confidential data; included with "Other."
[1] Includes secondary pig tin and tin acquired in chemicals.
[2] Includes pewter, britannia metal, and jewelers' metal.

STOCKS

Stocks of plant-held pig tin were 7% lower than in the corresponding period of 1972. Stocks dropped to a low of 5,050 tons in May, but resumption of commercial sales of pig tin by GSA were reflected by a rise in plant-held stocks to a high of 10,200 tons at the end of August. Drawdown of pig tin stocks continued for the remainder of the year. Tinplate mills held 4,405 tons of pig tin at yearend. Tin in process and tin in transit in the United States recorded increases from 1972 levels, but the increases were more than offset by declines in stocks held by jobbers-importers and tin afloat to the United States. Total tin stocks at yearend were 23,992 tons, 5% below the yearend 1972 level and the lowest since 1951.

Table 9.—U.S. industry yearend tin stocks

(Long tons)

	1969	1970	1971	1972	1973
Plant raw materials:					
Pig tin:					
Virgin	12,281	9,451	7,779	r 8,152	7,509
Secondary	253	222	255	r 254	350
In process [1]	10,907	11,492	10,523	r 10,084	10,398
Total	23,441	21,165	18,557	r 18,490	18,257
Additional pig tin:					
In transit in United States	80	10	140	445	970
Jobbers-importers	1,210	1,635	1,630	2,720	1,135
Afloat to United States	5,865	3,500	4,510	3,725	3,630
Total	7,155	5,145	6,280	6,890	5,735
Grand total	30,596	26,310	24,837	r 25,380	23,992

r Revised.
[1] Tin content, including scrap.

PRICES

Prices of tin metal on world markets, in general, reflected conditions of supply, which ran the gamut from oversupply during the first 5 months of the year, through a tightening and balance of supply and demand during the next 5 months, to undersupply during the last 2 months. Factors making for market unpredictability included: ITC export controls and buffer stock sales; monetary problems of dollar devaluation and floating of the Malaysian dollar; U.S. tin stockpile sales; liquidation of the Williams, Harvey smelter; upward revision of the ITC buffer stock range and buffer stock restrictions; and the energy crisis.

Average prices for the year reached record highs on all markets. The average price for cash tin on the LME was £1960.44 per metric ton (218.04 cents per pound) compared with £1505.94 per metric ton (167.49 cents per pound) in 1972. The average Penang price for ex-works Straits tin was M$686.28 per picul[3] (213.55 cents per pound), compared with M$626.80 per picul (195.04 cents per pound) in 1972.

The Penang price for ex-works Straits tin began the year at M$625 per picul (194 cents per pound) and in general remained in the M$630 per picul range through May. The February devaluation of the dollar that moved U.S. and LME prices higher was not reflected in the Penang market. Tin supply tightened at the Penang market in June as Malaysia failed to meet its export quota for the quarter and prices rose. Malaysia floated its dollar in late June and prices dipped. After early July, the Penang price moved firmly into the upper sector of the buffer stock range. The buffer stock range was revised upward and export controls were dropped in September. The price remained firmly in the revised middle sector until late October when it moved into the upper sector. In November, the price penetrated the ITC ceiling price on its way to a record high in December. The move was caused by tight supply conditions aggravated by the buffer stock exit from the market and speculation. The price reached M$1,206 per picul (319 cents per pound) on December 10 but dropped off to end the year at M$815 per picul (254 cents per pound), substantially above the ITC ceiling of M$760 per picul (236 cents per pound).

Table 10.—Monthly prices of Straits tin for prompt delivery in New York

(Cents per pound)

Month	1972			1973		
	High	Low	Average	High	Low	Average
January	172.000	170.500	171.310	180.000	177.750	179.045
February	174.000	171.000	172.000	202 500	181.250	192.014
March	183.750	175.000	179.810	210.000	201.000	205.102
April	183.000	181.000	181.975	204.000	199.000	202.400
May	180.000	175.250	177.920	214.000	202.000	209.114
June	176.250	173.500	175.034	218.750	207.500	212.274
July	177.750	175.000	176.613	247.750	218.000	237.548
August	182.250	177.500	179.120	248.500	239.000	243.565
September	182.750	181.000	181.988	241.750	238.750	240.303
October	182.000	178.000	180.400	252.000	239.000	245.909
November	178.250	176.250	177.213	284.750	252.000	262.440
December	178.500	174.750	176.250	345.000	274.250	300.461
Average	183.750	170.500	177.469	345.000	177.750	227.558

Sources: American Metal Market for 1972 and Metals Week for 1973.

FOREIGN TRADE

Although GSA sales of surplus stockpiled tin became a source of supply in the middle of the year, as reflected by a 13% drop in metal imports in 1973, the United States continued to rely upon foreign sources for the majority of its pig tin requirements. Of the 45,845 tons of tin metal imported into the United States, Malaysia furnished 62%; Thailand, 17%; and Australia and Indonesia, combined, 10%. The People's Republic of China was the fifth largest supplier of tin metal to the United States in 1973.

Imports of tin-in-concentrate destined for the Texas City, Tex., smelter totaled 4,480 tons in 1973. Bolivia furnished 4,464 tons and the Republic of South Africa, 16 tons.

Exports of metal from the United States trebled to 3,406 tons.

Small tonnages of secondary tin enter the United States as alloy constituents in recyclable solders or other alloys, or as tinplate or other scrap, dross, skimmings, and residues. These volumes find their way into consumption figures and account for the differences normally encountered between U.S. production and consumption of secondary tin. Tin that is a constituent alloy in imports and exports of babbitt, solder, type metal, and bronze is shown in the Minerals Yearbook chapters on "Copper" and "Lead." Ferrous scrap exports, including those of tinplate and terneplate scrap, are not classified separately.

[3] One Malaysian dollar (M$) = US$0.4149; one picul = 133.33 pounds.

Table 11.—U.S. exports and imports for consumption of tin, tinplate, and terneplate in various forms

Year	Ingots, pigs, and bars: Exports: Quantity (long tons)	Ingots, pigs, and bars: Exports: Value (thousands)	Ingots, pigs, and bars: Reexports: Quantity (long tons)	Ingots, pigs, and bars: Reexports: Value (thousands)	Tinplate and terneplate: Exports: Quantity (long tons)	Tinplate and terneplate: Exports: Value (thousands)	Tinplate and terneplate: Imports: Quantity (long tons)	Tinplate and terneplate: Imports: Value (thousands)	Tinplate circles, strips and cobbles, exports: Quantity (long tons)	Tinplate circles, strips and cobbles, exports: Value (thousands)	Tinplate scrap, imports: Quantity (long tons)	Tinplate scrap, imports: Value (thousands)
1971	1,821	$6,648	441	$1,620	186,151	$39,605	372,875	$80,562	8,675	$1,186	18,071	$546
1972	857	2,915	277	1,055	245,355	51,929	466,455	107,844	4,076	552	15,214	437
1973	2,540	12,099	866	3,236	354,393	89,704	419,915	105,597	21,563	2,678	11,940	384

Table 12.—U.S. imports for consumption and exports of miscellaneous tin, tin manufactures, and tin compounds

Year	Miscellaneous tin and manufactures: Imports: Tinfoil, tin powder, flitters, metallics, tin and manufactures, n.s.p.f., value (thousands)	Miscellaneous tin and manufactures: Imports: Dross, skimmings, scrap, residues, and tin alloys, n.s.p.f.: Quantity (long tons)	Miscellaneous tin and manufactures: Imports: Dross, skimmings, scrap, residues, and tin alloys, n.s.p.f.: Value (thousands)	Miscellaneous tin and manufactures: Exports: Tin scrap and other tin-bearing material, except tinplate scrap, value (thousands)	Tin compounds imports: Quantity (long tons)	Tin compounds imports: Value (thousands)
1971	$4,472	4,125	$1,385	$1,780	91	$257
1972	6,501	1,304	2,140	3,392	152	477
1973	6,956	1,281	1,322	3,262	154	645

Table 13.—U.S. imports for consumption of tin[1] by country

Country	1972 Quantity (long tons)	1972 Value (thousands)	1973 Quantity (long tons)	1973 Value (thousands)
Australia	2,184	$7,468	1,963	$8,261
Belgium-Luxembourg	71	277	118	521
Bolivia	1,104	4,172	832	3,821
Brazil	696	2,620	594	2,676
Canada	274	1,067	25	109
Chile	93	354	--	--
China, People's Republic of	160	639	1,727	7,801
France	20	73	--	--
Germany, West	99	359	--	--
Hong Kong	20	73	172	720
India	175	650	10	43
Indonesia	1,997	8,126	2,829	12,016
Japan	25	91	--	--
Malaysia	32,645	120,780	28,255	121,469
Mexico	--	--	67	136
Netherlands	163	451	45	241
Nigeria	184	691	105	419
Peru	128	492	--	--
Singapore	129	469	--	--
Taiwan	86	324	251	1,085
Thailand	11,727	44,393	7,964	32,164
United Kingdom	471	1,852	888	3,764
Total	52,451	195,421	45,845	195,246

[1] Bars, blocks, pigs, grain, or granulated.

WORLD REVIEW

INTERNATIONAL TIN AGREEMENT

The International Tin Council (ITC) operating under the Fourth International Tin Agreement (ITA), had an active year trying to control the tin situation. Large buffer stock holdings, a production surplus, and low tin prices forced the adoption of export controls on producer nations for the first quarter of the year. The possibility of unforeseen supply-demand problems developing because of GSA tin sales forced the retention of export controls through September 30. Inflation and an unstable monetary base forced an upward revision of the price range in late September. High demand, failure of some producing nations to meet export quotas, the closure of a major tin smelter, and the energy crisis caused a tight metal supply and led to a yearend shortfall of 23,000 tons between mine production and consumption. Prices rose above the ITC ceiling price to record highs, forcing curtailment of buffer stock operations, the only method available to the ITC for maintaining the ceiling price.

With the price of tin in the lower sector of the price range and over 12,000 tons of tin in the buffer stock, the ITC at its January meeting decided to impose export controls on member producing nations from January 19 to 31.

In March the ITC decided to retain export controls for the second quarter but cut the permissible tonnage 2.5% from the average 1972 export level and extended authorization for the buffer stock manager to operate in the middle sector.

A special session of the ITC met in July to consider revision of the floor and ceiling prices after floating of the Malaysian dollar. Since the value of the Malaysian dollar was only allowed to float upwards while the British pound floated freely, and the U.S. market was under the influence of GSA tin sales, the ITC decided not to revise price levels or the monetary base.

By the time of the ITC's mid-September session, the price of tin was firmly in the upper sector of the price range, GSA had sold its tin allocation for the year but had reentered the market because of the tight metal supply, and the buffer stock contained only 4,744 tons. Export control was dropped as of September 30, and authorization for the buffer stock manager to operate in the middle sector was withdrawn. Effective September 21, the price range was revised upward for the first time since October 21, 1970, after a compromise by the consuming and producing nations. The producing nations desired a 20% increase in the floor and ceiling price to compensate for inflation. The consuming nations felt a 5% increase was sufficient. The price range was revised as follows:

	Previous range		Revised range	
	M$/picul	U.S. equivalent, cents/pound	M$/picul	U.S. equivalent, cents/pound
Floor price	583	181	635	198
Lower sector	583–633	181–197	635–675	198–210
Middle sector	633–668	197–209	675–720	210–224
Upper sector	668–718	209–223	720–760	224–236
Ceiling price	718	223	760	236

In October, the ITC made known its position on U.S. stockpile sales. The ITC wished to be assured the following possibilities would not occur because of U.S. stockpile releases:

(a) Unacceptably low prices, leading to severe losses in the export earnings of producing countries and the closure of large sections of the mining industry, and consequent unemployment; whole sections of a country's or region's industry could be at risk.

(b) Breakdown of productive capacity or unwillingness to invest in new capacity, leading eventually to serious shortages of tin and excessively high prices; the larger the scale of the tin disposal program is, the more likely such shortages could eventually be.

(c) Serious prejudice to the objectives and work of the Council which has been carefully built up over the years; the buffer stock operations and export controls are currently operated in relation to commercial market conditions without extraneous supplies from non-commercial sources.[4]

By November 10 tin metal supply was so tight that even with combined GSA and buffer stock sales of over 15,000 tons, the price exceeded the ITC ceiling price. The buffer stock manager was released from the responsibility of supporting the ceiling price at the risk of exhausting the buffer stock. The price of tin rose to record highs in early December, and closed the year well above the ITC ceiling price.

During the year, the buffer stock levels continuously fell from 12,282 tons in January to 985 tons in December. The French Government contributed $3 million to the buffer stock fund. Ireland, Romania, and Turkey joined the Fourth ITA as consuming nations and the votes were adjusted as follows:

Austria	10	Italy	58
Belgium-Luxembourg	27	Japan	214
Bulgaria	11	Korea, Republic of	9
Canada	40	Netherlands	42
Czechoslovakia	30	Poland	35
Denmark	10	Romania	24
France	82	Spain	30
Germany, West	108	Turkey	14
Hungary	15	United Kingdom	121
India	34	U.S.S.R	64
Ireland	6	Yugoslavia	16
		Total	1,000

The producing nations' votes remained as established on October 1, 1972.

[4] International Tin Council (London). The International Implications of United States Disposal of Stockpiled Tin. October 1973, p. 27.

Table 14.—Tin: World mine production, by country [1]
(Long tons)

Country	1971	1972	1973 p
North America:			
Canada	142	161	e 2 138
Mexico	471	348	287
United States	W	W	W
South America:			
Argentina	700	542	e 550
Bolivia [3]	29,533	31,056	29,825
Brazil	2,065	2,769	e 2 3,158
Peru (recoverable)	r 167	130	218
Europe:			
Czechoslovakia	166	157	e 2 162
France	344	308	e 310
Germany, East e	4 1,000	4 1,000	1,100
Portugal	546	520	525
Spain	396	373	323
U.S.S.R. e	28,000	28,500	29,000
United Kingdom	1,787	3,274	3,604
Africa:			
Burundi	r e 2 100	110	e 110
Cameroon	r 25	24	e 2 35
Congo e 2	47	47	47
Morocco	8	8	10
Niger	r 79	81	83
Nigeria	7,210	6,625	5,736
Rhodesia, Southern e	600	600	600
Rwanda e	1,300	1,300	1,300
South Africa, Republic of	1,997	2,125	2,634
South-West Africa, Territory of (recoverable)	949	979	779
Swaziland e 2	12	12	12
Tanzania	r 136	51	23
Uganda	r 128	79	43
Zaire	6,354	5,799	5,453
Zambia e 2	24	24	24
Asia:			
Burma	672	646	756
China, People's Republic of e	20,000	20,000	20,000
Indonesia	19,411	20,992	22,135
Japan	777	859	796
Korea, Republic of	5	1	8
Laos	774	e 820	e 900
Malaysia	74,253	75,617	71,119
Thailand	21,346	21,723	e 2 20,232
Oceania: Australia	r 9,877	11,950	10,369
Total	r 231,401	239,610	232,404

e Estimate. p Preliminary. r Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Data derived in part from the Statistical Bulletin of the International Tin Council, London, England.
[2] Estimate by International Tin Council.
[3] Total of COMIBOL output, COMIBOL purchases from lessees operating in COMIBOL mines, and medium and small mines' sales to ENAF plus exports.
[4] Estimate according to the 60th annual issue of Metal Statistics (Metallgesellschaft).

Table 15.—Tin: World smelter production, by country [1]

(Long tons)

Country	1971	1972	1973 p
North America:			
Mexico	471	348	287
United States [2]	4,000	4,300	4,500
South America:			
Bolivia [3]	7,116	6,405	e 7,700
Brazil	r e 4 3,370	3,526	e 4 3,600
Europe:			
Belgium	3,878	3,861	3,611
Germany, East e	5 1,100	r 5 1,100	1,100
Germany, West	1,151	845	1,024
Netherlands	824	--	--
Portugal	476	596	516
Spain	4,584	4,206	4,191
U.S.S.R. e	28,000	28,500	29,000
United Kingdom	22,787	20,996	16,764
Africa:			
Morocco e	12	12	12
Nigeria	r 7,232	6,637	5,889
Rhodesia, Southern e	600	600	600
South Africa, Republic of	r 702	767	860
Zaire e 4	1,330	1,400	1,400
Asia:			
China, People's Republic of e	20,000	20,000	20,000
Indonesia	9,074	11,819	14,401
Japan	r 1,263	1,329	1,329
Laos	696	r e 817	e 820
Malaysia [6]	85,719	89,564	81,166
Thailand	r 21,399	21,929	e 21,626
Oceania: Australia	6,233	6,916	6,795
Total	r 232,017	236,473	227,251

e Estimate. p Preliminary. r Revised.
[1] Data derived in part from the Statistical Bulletin of the International Tin Council, London, England.
[2] Includes tin content of alloys made directly from ores.
[3] Tin content of production from Metabol and Pero smelters plus exports by ENAF smelter.
[4] Estimate by International Tin Council.
[5] Estimate according to the 60th annual issue of Metal Statistics (Metallgesellschaft).
[6] Includes small production of tin from the smelter in Singapore.

Australia.—The Australian Government announced stricter controls on mining development and export prices of all minerals produced in an effort to ensure that Australian mineral wealth would benefit the nation and be sold at reasonable prices. The upward revaluation of the Australian dollar severely affected the Australian mining industry. Tin export controls reduced tin mine production by 13% and metal production by 2%.

Renison Ltd., Australia's largest tin producer, reported a slight drop in output because of a 3-month strike. Although the amount of ore treated was down 20% from that of 1972, the grade of ore rose from 1.30% to 1.49% and the recovery of tin-in-concentrate increased from 66% to 71% so the tonnage of tin-in-concentrate sold decreased only slightly to 3,809 tons compared with 3,845 tons in 1972. Renison announced an increase in tin ore reserves from 7,149,000 tons to 7,928,000 tons, with ore grade increasing from 1.30% to 1.34%. The installation of a heavy-media separation plant, to be completed in mid-1974, will increase mill throughput from 450,000 to 700,000 tons per year and enable treatment of lower grade ore.

The Aberfoyle group, consisting in part of Aberfoyle Ltd., Ardlethan Tin N.L., and Cleveland Tin N.L., reported disappointing earnings for its latest fiscal year because of fluctuating tin prices, increased operating costs, and the failure of the Storeys Creek mine.

Bolivia.—Of the 29,825 tons of tin-in-concentrate produced in 1973, COMIBOL contributed 20,515 tons, the medium miners 6,773 tons, and the small miners 2,537 tons.

Total tin exports were 27,950 tons, down 6% from the previous year's level. The Empresa Nacional de Fundiciones (ENAF), the national smelting company, increased its metallic tin exports from 6,158 tons in 1972 to 6,754 tons in 1973. ENAF sold 300 tons of electrolytic tin to Argentina, which ENAF felt may open the door to an expanded Argentine market for Bolivian tin metal.

ENAF obtained a loan from West Germany for plant equipment and machinery to expand the capacity of the Vinto smelter from 7,400 tons to 10,800 tons. The first stage was scheduled for completion by mid-1975 with final expansion to 19,700 to be completed by mid–1976.

Following the liquidation of the Williams, Harvey & Co., Ltd., smelter, which had been smelting the bulk of Bolivia's high-grade tin concentrate, the Bolivian Government contracted with Capper Pass & Son, Ltd., in the United Kingdom to take over smelting program. COMIBOL agreed to ship up to 6,000 tons of tin-in-concentrate per year for the next 3 years. Bolivia accepted a penalty readjustment in smelting fees as compensation for atmospheric contamination and another penalty for arsenic content. Overall, it is expected that smelting under the new contract will cost Bolivia about $1.3 million more each year than under the old contract. In addition, Bolivia can expect to collect only half of the $8.25 million debt owed by the Williams, Harvey smelter. Other smelters of Bolivian ore are located in the United States, Brazil, Mexico, Spain, and West Germany.

COMIBOL announced that its output of tin should reach 28,000 tons by 1980. Most of the increase is expected to come from more efficient recovery by extensive use of volatilization plants and new preconcentrating plants and techniques.

W. R. Grace & Co. sold its 75% interest in Estaños Aluviales, S. A. (ESTALSA), which operates a tin dredge and two washing plants, and its 57% interest in the International Mining Co. (IMCO), which operates an underground tin-tungsten mine. Tin production from these operations has been in the 2,000- to 2,300-ton range.

Brazil.—The Brazilian Industry and Trade Ministry concluded studies for the planning and development of Brazil's nonferrous metals industry. The Government will spend $16 million on a 2-year tin exploration and development program. Projected tin production of at least 7,500 tons per year by 1980 and projected consumption of 6,000 tons per year should allow Brazil to maintain its net export status.

In the Rondônia Area, Mineração Aracazeiro and Mineração Brasiliense (Mibrasa) blasted ore from bedded deposits. The deepest bed discovered so far, near Pôrto Velho, was 125 feet below the surface. W. R. Grace & Co. sold its 50% interest in Mibrasa to Brazilian interests. Tin production by Mibrasa has been about 750 tons per year.

Cia. Industrial Amazonense began operations at its new refinery in Manaus. The plant produces 78 tons of tin metal per month from Rondônian ores.

Canada.—Ecstall Mining Ltd., a subsidiary of Texas-gulf, Inc., installed a $5.5 million tin concentration circuit at the Kidd Creek mine near Timmins, Ontario. The new plant will recover fine cassiterite from tailings from the main plant. Bartles-Mozley wet gravity concentrator tables preconcentrate the byproduct tin to 0.7% tin. Further upgrading by tabling, flotation, and leaching produces a concentrate assaying 54% tin. Production of concentrate is expected to reach 700 tons per year.

Indonesia.—Even though operating under export controls for most of the year, Indonesia increased tin mine production 5% over the 1972 level to 22,135 tons, the highest level since 1960. Indonesia regained its position as the third largest tin producer, displacing Thailand. Increased output was attributed to the recent modernization by P.N. Timah of its bucket dredges and the introduction of new ore-dressing methods for improving cassiterite recovery. In accordance with Indonesia's new 5-year plan, tin mine output is targeted at 25,000 tons for 1974.

Two new seagoing bucket dredges, tentatively named *Bangka II* and *Bangka III*, were under consideration by P.N. Timah. Design will be similar to that of *Bangka I* to afford parts interchangeability, but the new dredges will be able to operate at a greater depth than the 130 foot-maximum of *Bangka I*. Firm financial arrangements have yet to be made.

P.T. Koba Tin, a joint venture owned 25% by the Indonesian Government and 75% by three Australian firms (Colonial Sugar Refining, Blue Metal Industries, and Ready Mixed Concrete, a subsidiary of Blue Metal) was the first overseas joint venture company to commence tin mining in Indonesia since independence in 1945. P.T. Koba Tin operated two gravel pumps and planned to install three more by early 1974. Production is expected to exceed 800 tons of tin concentrate in 1974.

P.T. Broken Hill Pty. Indonesia began rehabilitating the Kalapa Kampit lode mine on Bilitung. Production prior to its closure in 1942 reached 2,000 tons of tin-in-concentrate per year. After dewatering of a section of the mine, operations will resume at an initial rate of 100 tons of ore per day.

Malaysia.—Malaysia continued to lead the world in production, smelting, and exports of tin in 1973. A total of 71,119 tons of tin-in-concentrate was mined, the lowest level since 1966 and down 6% from the previous year's production because of export controls, heavy flooding during May in many mining areas, and low prices of tin during the first half of the year. At yearend there were 58 tin dredges, 873 gravel pump mines, and 43 opencast, underground, and other miscellaneous mines in operation, reflecting a 7% drop in total active mines through the year. The gravel pump mines bore the brunt of the decreased mining activity with a loss of 67 mines during the year.

Gravel pump operations, worked for the most part by the same families that own the mines, accounted for about 54% of the concentrate produced, while dredging by corporations furnished another 31%. Opencast mines brought in 5% of the ore produced, underground mines accounted for 3%, and the remaining 7% came from miscellaneous sources. The tin-mining labor force declined 9% to 41,744 workers at yearend.

Metal production, at 81,166 tons, was 9% below the 1972 level and the lowest since 1967. Exports of metal declined to 80,397 tons from 86,063 tons in 1972.

Perbadanan Nasional Berhad (Pernas), Malaysia's national mining corporation, was granted tin exploration rights to a concession of over 15,000 square miles offshore from Penang, Perak, and Selangor States. After an initial 3-year exploration period, Pernas can apply for a mining lease for 5% of the area. The remainder of the concession will revert to the Malaysian Government, but Pernas will retain first option on the areas surrendered.

Several new dredges started operations during the year. Conzinc Riotinto Malaysia Sdn. Berhad, a joint venture between Rio Tinto-Zinc (41.25%), Conzinc Riotinto of Australia Ltd. (13.75%), and Bethlehem Steel Corp. (45%), started dredging for tin at Labohan Dagong, Selangor. The 5,300-ton dredge built by IHC Holland can dig to a depth of 150 feet and has an annual throughput of 10 million cubic yards. The dredge has circular jigs and produces a low-grade concentrate prior to further upgrading onshore. Selangor Dredging Berhad's No. 2 dredge began operation late in 1973. The $4.7 million 24-cubic-foot bucket dredge is capable of annual throughput of 12 million cubic yards.

Other new dredges were in the planning stage. Selangor State Development Corp. contracted for the design of its first dredge. The $4.1 million dredge, scheduled to begin mining in 1976, will be operated by the corporation's subsidiary, Syarikat Timah Langat Sdn. Berhad, on a 2,000-acre area at Dengkil in Selangor's Kuala Langat forest reserve.

Berjuntai Tin Dredging Berhad, the largest private tin-mining company in the world, decided to proceed with the construction of its eighth bucket dredge. The new dredge will have 22-cubic-foot-capacity buckets, monthly throughput of 600,000 cubic yards, and a maximum dredging depth of 130 feet. Reserves sufficient for 11 years of operation have been allocated for the dredge. When No. 8 begins production, Berjuntai will close down its No. 1 dredge, which has been mining in Selangor for nearly 50 years. Berjuntai's tin concentrate production was down 366 tons to 4,551 tons for its fiscal year because of the lower grade ground worked by all but the No. 7 dredges. The two newer 20-cubic-foot bucket dredges, Nos. 6 and 7, produced 2,248 tons of concentrate, or about as much as the five older units combined. Output reached 2,467 tons, compared with 2,197 tons for the corresponding period in 1972.

Malayan Tin Dredging Ltd., and Southern Malayan Tin Dredging Ltd., had reduced outputs during the fiscal year 1973. Malayan Tin plans to divert the River Kinto so an additional 368 acres of land on its Kampong Gajah property will be available for dredging. The project is expected to be completed in 1979. The work will proceed in stages so the company's dredges can work systematically through the area.

Ayer Hitam Tin Dredging, Ltd., reported increased output of 3,469 tons in fiscal 1973, compared with 3,109 tons in

1972. Production during the fiscal year is expected to decrease because lower grade ground is being worked and the No. 2 dredge was temporarily shutdown.

Sungei Besi Mines Ltd., operating three opencast mines in southeastern Selangor, had a record production in fiscal year 1973 of 2,472 tons of concentrate assaying 74.3% tin. Stripping operations continued at the new 3/5 mine, with production scheduled to start in 1974.

Gopeng Consolidated Ltd., produced 2,686 tons of concentrate during the year, slightly less than in 1972. Gopeng purchased 2,167 acres of land, some of which is to be used for dumping tailings. This will ease the company's task in meeting Government water purification requirements prior to returning water to the normal river courses. Gopeng also concluded a lease-purchase agreement for 541 acres of mining land in the Batang Pedang district of Perak.

Pahang Consolidated Co., Ltd., whose mine at Sungei Lembing is the largest lode tin venture in Southeast Asia, produced 2,535 tons of concentrate, slightly less than during 1972. Pahang realized $3.5 million through the sale of its wholly owned subsidiary, The Kuala Reman Rubber Estates. Some of the funds will be used in sinking the Gakak shaft and installing a new heavy-media separation plant. Ore reserves are estimated at 11,500 tons of contained cassiterite.

Pacific Tin Consolidated Corp., the only U.S. company mining tin in Malaysia, showed decreases in total yardage treated and tin recovered in 1973. The No. 5 dredge was shutdown in February when its minable reserves were exhausted. Dredge No. 8, operating at Batang Berjuntai, dug 56% of the total yardage and produced 43% of the total tin recovered by all plants in 1973. Dredge No. 2 operated on leases along the Selangor River. Four gravel pump mines operated in the Ampang area, but one was closed down in September after allocated reserves were exhausted. Estimated tin ore reserves at yearend were about 8,000 tons.

A new regional tin center will be constructed in Ipoh by the Conference of Asian Nations on Geology. The center will conduct research on better methods of mining and treating tin ore.

Nigeria.—Production of tin in Nigeria declined for the fifth consecutive year to 5,736 tons, its lowest level since 1959. Over the past several years, spiraling production costs had lowered the profit margin of operators to a point where significant reinvestment and exploration programs had to be curtailed, forcing rapid depletion of minable ore bodies. In May, the Government changed the royalty levied on tin production from 17% to a sliding scale of 11% to 16% based on world price. The new rates were retroactive to April 1. The lower royalty should help encourage reinvestment in the hard-pressed tin industry.

Amalgamated Tin Mines of Nigeria Ltd., the largest tin producer in Nigeria, reported a 7% drop in tin concentrate production to 3,464 tons for the year ending in March, but had higher profits for the year because of improved tin prices. Production was adversely affected by heavy rains. Prospecting activities increased as the company sought extensions of alluvial deposits under the basalt.

Gold & Base Metal Mines of Nigeria Ltd., continued exploration at its Liruie project in Kano State. Five exploratory shafts were sunk to varying depths along a strike length of 4,550 feet. The lode ranges in width from 7 to 8 feet and contains an average of 0.8% tin and 3.42% zinc, calculated over a minimum mining width of 5 feet. Planned throughput was based on 900 tons per day.

South Africa, Republic of.—The two major South African producers, Rooiberg Minerals Development Co. Ltd. and Union Tin Mines Ltd., reported higher tin concentrate recoveries during their fiscal years, partially the result of successful operation of new flotation plants. Rooiberg's output increased 28% to 1,891 tons of tin-in-concentrate. Flotation recoveries by Union Tin increased to 551 tons compared with 205 tons in 1972, but gravity concentrate recoveries dropped to 147 tons from 376 tons in 1972. Total increase in tin concentrate output was about 20%.

Thailand.—Tin production decreased 7% to 20,232 tons in 1973 as heavy monsoon rains, the 3-month breakdown of the sea dredge *Temco II*, and the diesel oil shortage forced mine closures and production cutbacks. By yearend, about the same number of tin mines were in operation as at yearend 1972, because the number of gravel pump mines that closed was offset by an increased number of tin-tungsten operations. Of the 656 mines in operation, there were 25 dredges (17 inland, 8 offshore), 266 gravel pump mines, 8 hydraulic mines, 108 ground sluicing operations, 216 tin-tungsten mines, and 33 miscellaneous operations.

Southern Kinta Consolidated Ltd. modified its Takuapa near-shore suction dredge by increasing pumping capacity by 8,000 gallons per minute, enlarging suction dragheads, installing hydrocyclones for dewatering, and adding more swell compensators and longer suction pipes to enable operations to 60-foot depths where necessary. Southern Kinta's output increased 63% over the 1972 level to 856 tons of tin concentrate in 1973.

Tronoh Mines Ltd. reviewed designs of dredging equipment capable of round-the-clock operation throughout the monsoon season to determine whether tin deposits discovered on the west coast of Thailand could be economically exploited. Thai Tin & Tungsten Corp., a subsidiary of Pickands-Mather & Co., was acquired by Faber Merlin Ltd. Thai Tin and Pacific Tin Consolidated Corp. had been developing an underground tin-tungsten mine at Sichon in southern Thailand. Faber Merlin expects to bring the Sichon mine to the preproduction mill-testing stage by the end of 1974, with an initial mill throughput of 3,000 tons per month to yield 30 tons of tin and 4 tons of tungsten. Faber Merlin Thailand, 41.4% owned by Faber Merlin Ltd., purchased St. Piran Mining Ltd.'s Thai mining interests comprised of five dredges operated by Siamese Tin Syndicated Ltd. and Bangrin Tin Dredging Co., Ltd.

United Kingdom.—Consolidated Tin Smelters Ltd., announced the voluntary liquidation of the Williams, Harvey & Co., Ltd., smelter as the result of continuing monetary losses. Rundown operations at the smelter, located in Kirkby, continued until the end of December, but efforts to locate a new operator failed. The smelter was the larger of the two United Kingdom smelters, producing about 16,700 tons of primary metal in 1972. The smelter, built at a cost of $14.7 million 4 years ago, was never able to operate at a profit because of the high transportation costs and the difficulty of processing Bolivian concentrate, its main feed source. Capper Pass & Son Ltd., agreed to process the Bolivian concentrate previously sent to Williams, Harvey.

South Crofty, Ltd., a wholly owned subsidiary of St. Piran Mining Co. Ltd., purchased the Pendarves tin mine, which had been placed in receivership early in the year by Camborne Mines Ltd. Operations at the Pendarves mine will be integrated with those of South Crofty. The spare capacity of the South Crofty mill will be used to treat Pendarves ores. The South Crofty mine produced 1,529 tons of tin concentrate in 1973, down slightly from 1972 production.

Wheal Jane Ltd., a subsidiary of Consolidated Gold Fields, Ltd., produced 1,585 tons of tin-in-concentrate during 1973, 185 tons over its initial projected rate of 1,400 tons per year. Deepening and reequipping of the Clemow shaft was completed in January, allowing increased production even though ore grade was running lower than the anticipated 1.25% tin.

Cornwall Tin & Mining Corp. concluded financing arrangements which will enable it to bring its Mount Wellington property into production. The property, situated next to the Wheal Jane mine, has indicated reserves in excess of 5 million tons averaging 1.37% tin with associated copper and zinc.

TECHNOLOGY

Geochemical techniques for tin prospecting in British Columbia and the Yukon Territory in Canada were discussed.[5] The most practical analytical techniques were evaluated, including a spectrophotometric method and geochemical field kit. Suggestions were made for sampling soil horizons and rocks; a simple "heavy minerals collector" for stream sediment sampling was described; and arsenic, copper, fluorine, lead, molybdenum, tin, and zinc contents of various samples were analyzed by graphical and computer methods.

The metallogenetic basis of tin exploration in the Erzebirge mining district of

[5] Barakso, J. H., and J. A. Gower. Geochemical Prospecting for Tin. Western Miner, v. 45, No. 2, February 1973, pp. 37–44.

East Germany was described.[6] Factors and indicators critical in exploration for concealed endogenetic-epigenetic tin deposits were discussed. Leaching and redeposition in the formation of tin deposits were related, and a model concept was developed for the formation of endogenetic-epigenetic tin deposits.

The analytical system used to control the continuous flotation process at the Wheal Jane ore-processing plant allowed profitable mining of the previously uneconomic ore.[7] Mineralogical difficulties, such as a high concentration of sulfide minerals in the ore and finely disseminated cassiterite, that had stymied previous operators were overcome by frequent computerized X-ray spectrometer analysis of samples taken at all stages of the process. A description of the flotation methods used by Consolidated Gold Fields Group at its Wheal Jane mine as well as its three other lode tin mines was published.[8] A British patent was issued for a technique for gravity concentration of cassiterite from slimes.[9] Recoverey of particles in the 5- to 100-micrometer range was said to be possible.

The Australian Defence Standards Laboratories obtained favorable results in its study of antifouling systems of organotins in elastomer-toxicant combinations.[10] Compounds investigated were tri-n-butyltin oxide, tri-n-butyltin acetate, and tri-n-butyltin fluoride. Elastomers studied were natural rubber, nitrile rubber, and polychloroprene.

Tri-n-butyltin oxide combined with dieldrin, a chlorinated hydrocarbon, was very effective in protecting wood against termite attack.[11]

A new class of superconducting alloys consisting of 90% copper and one or two superconducting metals such as columbium and tin was developed.[12] The new class is ductile and pliable and can be fabricated into wires, strips, and tubes. Recent developments in the application of centrifugal casting of tin-containing alloys were reviewed.[13] Substitution of tin and tin alloys of lead and nickel for gold in the electronics industry became more widespread as the price of gold increased.[14] Tin alloyed with silver-antimony and lead-silver was being used by the automotive industry in special bonding preforms for new electronic ignition systems.[15]

The use of solder preforms in industry was on the increase.[16] In most cases, the preforms are tin-lead alloys of 60% tin and 40% lead or 45% tin and 55% lead. Once in place, the preforms can be joined by conventional heating methods to form perfect solder fillets. A discussion was presented of the influence of component materials on the quality of soldered joints with emphasis on tin and tin-lead coatings applied by hot-dipping or by electrodeposition.[17]

A study showed that pulse plating was a very effective technique for the electrodeposition of silver-tin alloys of fixed composition.[18] It is a particularly effective technique for the preparation of high-quality Ag_3Sn coatings with minimal amounts of elemental silver and tin.

By diffusing a tin coating into a ductile steel sheet, a tin-rich surface can be obtained that improves the corrosion properties of the steel without significantly altering other properties.[19]

A detailed study was made of the kinetics of the catalytic oxidation of carbon mon-

[6] Tischendorf, G. The Metallogenetic Basis of Tin Exploration in the Erzebirge. Min. and Met. Trans. (Sec. B), v. 82, No. 795, February 1973, p. B9–B24.

[7] Lloyd, L. A., and P. Jackson. New Methods of Analysis and Recovery Revitalize Dormant British Tin Mine. Eng. and Min. J., v. 174, No. 2, February 1973, pp. 76–78.

[8] World Mining. How Gold Fields Floats Cassiterite at Four Mills. V. 9, No. 5, May 1973, pp. 42–44.

[9] Mozlez, R. H. (assigned to National Research Development Corp.). Method and Apparatus for Recovery Values from Cassiterite Slimes. British Pat. 1,327,039, Aug. 15, 1973.

[10] Quarterly Review, Tin Research Institute. Tin and Its Uses. Antifouling Systems Based on Organotins: Australian Navy Trials. No. 96, 1973, pp. 7–8.

[11] Quarterly Review, Tin Research Institute. Tin and Its Uses. Organotin-Dieldrin Combination Protects Wood Against Termites. No. 97, 1973, pp. 14–15.

[12] Chemical and Engineering News. V. 51, No. 14, Apr. 2, 1973, p. 8.

[13] Blanc, J. P. P. Centrifugal Castings in Tin-Containing Alloys. Tin Internat., v. 46, 1973, pp. 73–74.

[14] Patton, D. G. T. E. Sylvania Official Says Use in Electronics Will Decline. Am. Metal Market, v. 80, No. 232, Nov. 30, 1973, pp. 1, 7.

[15] American Metal Market. Say Alloys Turn On for Auto Ignitions. V. 80, No. 218, Nov. 9, 1973, p. 9.

[16] American Metal Market. Call for Mass-Produced Soldered Joints Increasing Use of Lead Alloy Preforms. V. 80, No. 110, June 6, 1973, p. 8.

[17] Ainsworth, P. A. Solderable Finishes for Electronic Assemblies. Metal Finishing J., v. 19, No. 219, 1973, pp. 114–117.

[18] Leidheiser, H., Jr., and A. R. P. Ghuman. Pulse Electroplating of Silver-Tin Alloys and the Formation of Ag_3Sn. J. Electrochem. Soc., v. 120, No. 4, April 1973, pp. 484–487.

[19] Thwaites, C. J., and E. A. Speight. Tin Diffusion Coatings on Steel. J. Iron Steel Inst., v. 211, No. 7, 1973, pp. 475–480.

oxide from automobile exhaust using catalysts obtained by thermal activation of granular hydrous stannic oxide gel in the temperature range of 200° to 500°C.[20]

In February the Tin Research Institute opened a new office at 2600 El Camino Real, Palo Alto, California 94306. It will serve more efficiently the interests of tin users in the western United States.

[20] Fuller, M. J., and M. Warwick. The Catalytic Oxidation of Carbon Monoxide on Tin(IV) Oxide. J. Catalysis, v. 29, 1973, pp. 441–450.

Titanium

By F. W. Wessel [1]

Production of all titanium commodities increased during 1973. Ore production benefited from a full year's operation by Titanium Enterprises in Clay County, Fla., and the opening of the American Smelting and Refining Company (Asarco) plant at Manchester, N.J. Pigment production increased because of plant expansions, principally that of E. I. du Pont de Nemours & Co. at New Johnsonville, Tenn. Industrial demand for titanium metal rose sharply during the last quarter.

Midyear indications of decreased housing starts had no apparent effect on the demand for pigment. Plastics industry demand was particularly strong, increasing about 35% over the previous year. The paper industry also is trending toward use of more pigment per unit weight of paper.

Worldwide criticism of waste-disposal practices at sulfate-process pigment plants prompted producers to adopt some type of pollution control. One European producer estimated a 15% increase in cost of product as a result. New sulfate-process capacity, accordingly, is being contemplated mainly in the less industrialized nations. Chloride-process plants, however, were being approached cautiously because of a limited world rutile supply.

Imports of natural rutile decreased about 15%, but imports of synthetic rutile increased appreciably. New or expanded facilities for ilmenite upgrading were under construction or on the drawing board in Australia, Canada, Japan, Taiwan, and the United States as the year ended. Ilmenite imports increased sharply during the year, but imports of Sorel slag and titanium pigment declined, in the latter case because of higher prices outside the United States.

Price increases in all sectors were prevalent and generally substantial. Ilmenite prices were up about 50%, rutile prices increased by 77%, and Sorel slag by more than 20%. Titanium sponge prices were about 8% higher at yearend. Only pigment prices, controlled by the Cost of Living Council, were slow to rise.

The political situation in Australia was such as to inhibit new mining investment;

[1] Physical scientist, Division of Nonferrous Metals—Mineral Supply.

Table 1.—Salient titanium statistics

	1969	1970	1971	1972	1973
United States:					
Ilmenite concentrate:					
Mine shipments________short tons__	893,034	920,964	713,610	743,401	813,400
Value________________thousands__	$18,636	$18,626	$15,936	$17,234	$21,041
Imports_______________short tons__	28,524	96,123	28,093	14,836	69,691
Consumption_______________do____	1,003,501	972,314	898,783	786,384	807,733
Titanium slag:					
Imports___________________do____	82,329	134,996	152,661	298,259	237,248
Consumption_______________do____	138,553	129,247	143,554	264,095	281,791
Rutile concentrate, natural and synthetic:					
Imports___________________do____	204,898	243,259	227,784	220,535	208,808
Consumption_______________do____	185,432	189,172	225,498	242,758	276,907
Sponge metal:					
Imports for consumption_____do____	5,745	5,931	2,802	3,808	5,172
Consumption_______________do____	20,124	16,414	12,145	13,068	20,173
Price: December 31, per pound______	$1.32	$1.32	$1.32	$1.32	$1.42
World production:					
Ilmenite concentrate________short tons__	2,777,253	3,109,151	2,845,789	2,668,251	2,939,192
Titanium slag_________________do____	754,898	853,389	859,097	924,068	947,390
Rutile concentrate, natural_______do____	436,821	459,507	423,825	356,532	367,768

international capital is apparently finding the situation there somewhat less congenial than formerly.

At yearend a commission formed by the European Community was studying titanium pigment operations and seeking a solution to its waste disposal problems.

Legislation and Government Programs.—About midyear the stockpile objectives for both rutile and titanium sponge were revised to zero. Disposal of 17,385 tons of rutile was authorized by Congress; of this quantity, 13,756 tons was sold by yearend for a total of $2.75 million. While deliveries of sponge under the 1972 contracts continued, small quantities of older sponge in inventory were released for sale.

Government exploration assistance for rutile, available through the Office of Minerals Exploration, U.S. Geological Survey, remained at 75% of the approved cost of exploration. The depletion allowance for ilmenite and rutile remained at 22% for domestic deposits and 14% for foreign deposits.

DOMESTIC PRODUCTION

Concentrates.—Production and shipments of titanium-mineral concentrate in 1973 increased 12.9% and 9.4%, respectively; the quantity of TiO_2 contained in the shipments increased 11.0%. The average grade of concentrate shipped was 57.4% TiO_2, a small increase over 1972 levels. The tonnage increases resulted from a full year's production at the new mine of Titanium Enterprises at Green Cove Springs, Clay County, Fla., and one-half year's production at the Asarco mine, Manchester township, Ocean County, N.J. Production continued at the mines of E. I. du Pont de Nemours & Co., Starke and Highland, Fla.; Humphreys Mining Co., Folkston, Ga.; SCM Corp., Glidden-Durkee Div., Lakehurst, N.J., and NL Industries, Inc., Tahawus, N.Y.

At Asarco's New Jersey property, construction was completed early in spring, and operations began in late June. The sand contains 4% heavy minerals; the concentrates contain 63% TiO_2. Some zircon and sillimanite are rejected. The sand reportedly contains no rutile. The dredge capacity is 1,200 tons per hour, but normal downtime, moving, etc., will limit daily production to an average of 20,000 tons. Operating capacity is estimated at 165,000 tons of product annually. The mine will probably operate for at least 20 years.

The Humphreys Mining Co. operation at Folkston, Ga., has probably had its last full year of operation at that locality. It is expected that the company will turn its attention to another sand deposit just within the Florida border and close enough to Folkston to permit trucking of the rough heavy-mineral concentrate to the dry plant there.

Ferroalloys.—Production of ferrotitanium increased to 1,156 tons in 1973, about 75% of the total representing the higher titanium-content alloys. Producers continued to be Shieldalloy Corp., Newfield, N.J., Union Carbide Co., Niagara Falls, N.Y., and Foote Mineral Company, Cambridge, Ohio. Scrap and ores were used as raw material.

Metal.—Production of titanium sponge was 50% higher than in 1972. Part of this increase was to fulfill General Services Administration contracts to procure the material for the Federal stockpile; shipments were made throughout the year by both producers. There was also a sharp increase in demand from industrial sources during the last 4 months of 1973. Producing companies were Titanium Metals Corp. of America (TMCA), Henderson, Nev., owned by NL Industries, Inc. and Allegheny Ludlum Steel Corp.; and RMI Co., Ashtabula, Ohio, owned by National Distillers & Chemical Corp. and United States Steel Corp.

Production of titanium ingot was 28,932 tons, a 43% increase over 1972 levels. As in 1972, the following nine companies produced ingot.

Company	*Plant location*
Crucible Steel Company of America.	Midland, Pa.
Howmet Corp	Whitehall, Mich.
Martin Marietta Aluminum, Inc	Torrance, Calif.
Oregon Metallurgical Corp	Albany, Oreg.
RMI Co	Niles, Ohio
Teledyne Titanium, Inc	Monroe, N.C.
Titanium Metals Corp. of America.	Henderson, Nev.
Titanium West, Inc	Reno, Nev.
TiTech International, Inc	Pomona, Calif.

Pigment.—Demand for all grades of titania pigment continued to be strong during 1973. Production increased 7.5% during the year, and shipments about 10.5%. Rutile-type pigment accounted for 72% of total production and was produced by all seven manufacturers. Anatase-type pigment was produced by five companies.

Strikes and mechanical difficulties are estimated to have cost the pigment industry more than 12,000 tons of production. At yearend, companies producing titania pigment, and their plant locations, were as follows: American Cyanamid Co., Savannah, Ga.; Kerr-McGee Chemical Corp., Hamilton, Miss.; E. I. du Pont de Nemours & Co., Antioch, Calif., Edge Moor, Del., and New Johnsonville, Tenn.; NL Industries, Inc., Sayreville, N.J., and St. Louis, Mo.; New Jersey Zinc Co. (a Gulf & Western Industries, Inc. unit), Gloucester, N.J., and Ashtabula, Ohio; SCM Corp., Glidden-Durkee Div., Baltimore, Md.; and Sherwin-Williams Chemical Co., Ashtabula, Ohio.

Du Pont's New Johnsonville plant capacity reached 228,000 tons per year by yearend. Work continued during the year at du Pont's Edge Moor plant, where chloride process capacity was replacing sulfate process units. The chloride-process plant will have 112,000 tons of annual capacity, and startup is scheduled for mid-1974. In April, du Pont's Pigments Department was considering construction of a 100,000-ton-per-year pigment plant on Colonel's Island, near Brunswick, Ga. Opposition from environmental groups was strong, however, concerning du Pont's plans for deep-well waste disposal. At last report the company was looking at alternate sites in the southeastern States.

Sherwin-Williams Co. and Rutile and Zircon Mines Ltd. (RZM), an Australian Company have concluded an agreement by which Sherwin-Williams will build a 50,000-ton-per-year plant to produce synthetic rutile on the basis of technology furnished by RZM. Completion is projected for late in 1974.

American Cyanamid Co. (Cyanamid) was notified early in January that its titania pigment plant in Savannah, Ga., was not in compliance with Georgia water-quality laws in its practice of discharging sulfate-process sludge into the Savannah River. At a cost of $80,000, Cyanamid obtained the right to use a process, developed by Ishihara Sangyo Kaisha, Ltd., for neutralizing acid wastes and thereby pro-

Table 2.—Production and mine shipments of titanium concentrates [1] from domestic ores in the United States

Year	Production (short tons, gross weight)	Shipments: Quantity (short tons gross weight)	Shipments: TiO_2 content (short tons)	Shipments: Value (thousands)
1969	931,247	893,034	480,918	$18,636
1970	867,955	920,964	487,298	18,626
1971	683,075	713,610	388,802	15,936
1972 [r]	695,727	743,401	420,887	17,234
1973	785,268	813,400	467,091	21,041

[r] Revised.
[1] Includes a mixed product containing rutile, leucoxene, and altered ilmenite.

Table 3.—Titanium metal data

(Short tons)

	1969	1970	1971	1972	1973
Sponge metal:					
Imports for consumption	5,745	5,931	2,802	[r] 3,808	5,172
Industry stocks	1,909	2,516	2,724	1,816	1,941
Government stocks (DPA inventories) [1]	20,385	19,994	19,994	19,994	18,706
Consumption	20,124	16,414	12,145	13,068	20,173
Scrap metal consumption	7,566	7,242	6,149	7,802	10,038
Ingot: [2]					
Production	28,490	24,331	18,387	20,267	28,932
Consumption	27,082	23,687	17,058	19,499	25,409
Net shipments of mill products [3]	15,940	14,480	11,241	12,627	14,530

[r] Revised.
[1] As of June 30 each year.
[2] Includes alloy constituents.
[3] Bureau of the Census, Current Industrial Reports Series BDCF-263.

ducing usable gypsum. In May, the Georgia Ports Authority announced its intent to issue revenue bonds to finance construction of pollution abatement facilities based on the Ishihara process. Ground was broken on September 19, and the treatment complex will be operating by the end of 1974. Universal Gypsum Co. of Georgia, a subsidiary of Universal Chemical and Mineral, Inc., will operate the new plant, the cost of which is estimated at $20 million.

Table 4.—Titanium pigment data

(TiO_2 content)

Year	Production (short tons)	Shipments[1]	
		Quantity (short tons)	Value, f.o.b. (thousands)
1969	664,253	654,490	334,521
1970	655,293	643,746	320,014
1971	677,751	684,698	311,140
1972	r 718,177	752,025	358,564
1973	p 772,392	NA	NA

p Preliminary. r Revised. NA Not available.
[1] Includes interplant transfers.

Source: Bureau of the Census.

CONSUMPTION AND USES

Concentrates.—Consumption of ilmenite was 3% greater than in 1972. Consumption of Sorel slag was 7% greater. Consumption of rutile, including the synthetic, increased 14%.

Metal.—Consumption of sponge and ingot increased 54% and 30%, respectively. Shipments of mill products gained 15% over those of 1972. Beginning about September 1, an increase in demand for titanium became evident, originating primarily in the industrial sector. As a material of chemical engineering construction, the metal found increased use in petrochemical plants, chlor-alkali cells, and copper-leaching hardware. Scrap consumed for making ingot increased 29% above 1972 levels. There is some evidence that about 4 million pounds of ingot went into inventories, principally those of consumers, during the year.

Pigments.—Preliminary figures showed a 10.5% increase in shipments. The quantity in excess of the 7.5% increase in production was accounted for, as in 1972, by delivery of imports and of pigment withdrawn from stocks. The plastics industry, consuming pigment at an accelerated rate during 1972 and most of 1973, showed indications of stabilized demand late in the year; the industry was operating near capacity, and some feedstocks were becoming harder to obtain.

Table 5.—Consumption of titanium concentrates in the United States, by product

(Short tons)

Year and product	Ilmenite[1]		Titanium slag		Rutile	
	Gross weight	TiO_2 content e	Gross weight	TiO_2 content e	Gross weight	TiO_2 content e
1969	1,003,501	541,840	138,553	98,075	185,432	178,090
1970	972,314	519,766	129,247	91,639	189,172	181,402
1971	898,783	486,271	143,554	101,751	225,498	215,916
1972:						
Alloys and carbide	(2)	(2)	(3)	(3)	(2)	(2)
Pigments	775,618	453,248	264,095	187,608	208,704	199,894
Welding-rod coatings and fluxes	(2)	(2)	(3)	(3)	11,022	10,392
Miscellaneous[4]	10,766	8,174	--	--	23,032	21,945
Total	786,384	461,422	264,095	187,608	242,758	232,231
1973:						
Alloys and carbide	(2)	(2)	(3)	(3)	--	--
Pigments	795,728	470,087	281,791	199,287	232,969	221,658
Welding-rod coatings and fluxes	(2)	(2)	--	--	10,635	10,059
Miscellaneous[4]	12,005	9,144	--	--	33,303	31,648
Total	807,733	479,231	281,791	199,287	276,907	263,365

e Estimate.
[1] Includes a mixed product containing rutile, leucoxene, and altered ilmenite.
[2] Included with "Miscellaneous" to avoid disclosing individual company confidential data.
[3] Included with "Pigments" to avoid disclosing individual company confidential data.
[4] Includes ceramics, chemicals, glass fibers, and titanium metal.

Table 6.—Distribution of titanium-pigment shipments, by industry

(Percent)

Industry	1969	1970	1971	1972	1973
Distribution by gross weight:					
Paints, varnishes, and lacquers	58.5	59.6	57.7	53.0	52.7
Paper	17.0	17.0	17.8	20.4	19.6
Floor coverings	2.3	1.8	2.1	2.1	1.3
Rubber	2.6	2.6	2.7	3.6	3.2
Coated fabrics and textiles (oil cloth, shade cloth, artificial leather, etc.)	1.3	1.3	1.0	1.5	1.3
Printing ink	2.3	2.2	2.1	2.1	2.0
Roofing granules	.9	.9	1.0	.3	.6
Ceramics	2.0	1.8	2.0	2.3	2.5
Plastics (except floor covering and vinyl-coated fabrics and textiles)	6.2	6.6	6.5	7.7	9.8
Other (including export)	6.9	6.2	7.1	7.0	7.0
Total	100.0	100.0	100.0	100.0	100.0
Distribution by titanium dioxide content:					
Paints, varnishes, and lacquers	54.3	55.8	54.4	52.0	52.5
Paper	19.5	19.3	19.7	20.9	19.8
Floor coverings	2.6	2.1	2.4	2.1	1.3
Rubber	3.0	3.0	3.0	3.7	3.2
Coated fabrics and textiles (oil cloth, shade cloth, artificial leather, etc.)	1.4	1.4	1.1	1.5	1.3
Printing ink	2.6	2.5	2.3	2.2	1.9
Roofing granules	1.1	1.0	1.1	.3	.6
Ceramics	2.4	2.1	2.2	2.4	2.6
Plastics (except floor covering and vinyl-coated fabrics and textiles)	7.1	7.6	7.1	7.9	9.8
Other (including export)	6.0	5.2	6.7	7.0	7.0
Total	100.0	100.0	100.0	100.0	100.0

STOCKS

In 1973, stocks of rutile in the United States continued to decline; yearend inventories were 9% below those at yearend 1972. Slag inventories decreased by 22% but ilmenite in inventories increased by 10% during the year. Yearend stocks of titanium sponge were 1,941 tons, and of titanium scrap 4,447 tons, representing increases of 7% and 2%, respectively. Figures for titanium scrap refer to metal in the hands of ingot and mill shapes producers only. An appreciable but undetermined quantity of scrap was in the inventory of steel and ferroalloy plants. Industry stocks of titanium dioxide declined for the third successive year, from 54,982 tons on January 1 to 34,122 tons at yearend—a 38% decrease.

Table 7.—Stocks of titanium concentrates in the United States, December 31

(Short tons)

	Gross weight	TiO_2 content [e]
Ilmenite:		
1971	645,107	383,113
1972 [r]	534,504	314,584
1973	586,714	334,441
Titanium slag:		
1971	108,265	76,741
1972 [r]	142,301	100,746
1973	111,014	78,373
Rutile:		
1971	236,955	225,925
1972 [r]	158,106	150,801
1973	143,181	135,546

[e] Estimate. [r] Revised.

PRICES

Concentrates.—Published price quotations for ilmenite, $22 to $24 per long ton at the beginning of 1973, increased to $32 on August 17 and to $38 on December 21. These figures are nominal; almost all domestic production of ilmenite is captive. Australian ilmenite prices increased to A$11–A$12 f.o.b. Australian ports. Indian ilmenite remained unchanged at £3.95 f.o.b. Indian west coast ports, and Malaysian ilmenite continued to bring £9.35 to £11.32 per metric ton c.i.f. British ports.

Rutile, bulk, f.o.b. cars at Atlantic and Great Lake ports, was quoted at $175 per short ton until May 18, when the price went to $210. On December 14 the price increased to $310, a 77% increase during the year. Corresponding prices in Australia were A$115 to A$125 per long ton until May, when quotations went to A$125 to A$130. In July another small increase became effective; quotations were A$127 to A$132 f.i.d. (free in container depot, a new basing point). Additional increases were noted in October and December; the yearend price was A$147 to A$152. Rutile released from the Federal stockpile during the last half of 1973 brought prices of $170 per short ton in August and $226 in November.

Titanium slag (70% to 71% TiO_2), quoted at $50 per long ton f.o.b. plant at Sorel, Quebec, went to $53 in mid-August and $60 at the yearend.

Manufactured Titanium Dioxide.—Continued heavy demand for all grades of pigment and increasing raw material costs permitted no relaxation of upward price pressures. In lots of 20 tons minimum, prices at yearend were within the following ranges:

	Prices (cents per pound)
Anatase:	
Paper grade	24–24½
Other grades	27½–29½
Rutile:	
Standard grade	27½–28½
Premium grades	28½–30

Material shipped as slurry was generally ½ cent per pound cheaper.

Late in December, one pigment maker announced prices, effective January 1, 1974, to be 30½ cents per pound for premium-grade rutile and 29½ cents per pound for standard-grade rutile and the higher anatase grades.

During the first half of 1973, several major European producers increased prices for pigment. The Kronos group of West Germany raised its prices 8% in European markets and 12% in markets outside Europe in March. In May, British Titan, Ltd., increased its prices by £18 per ton (approximately 2 cents per pound).

Metal.—Domestic sponge began the year at $1.32 per pound. The price increased to $1.42 to $1.45 in May, and ended the year at that level, although at the end of the year a further increase seemed imminent. Sponge imported from Japan, priced at $1.20 to $1.25 at yearend 1972, went to $1.34 to $1.37 in May, to $1.28 to $1.33 in August, and finally ended the year in the $1.36 to $1.38 range.

FOREIGN TRADE

Titanium dioxide exports in 1973 amounted to 20,769 tons, double the 1972 figure. Of this total, Japan received 20%, other Far East countries 31%, Western Europe 17%, Latin America and the West Indies 16%, and Canada 11%. Exports of unwrought, waste, and scrap titanium were 18% higher than in 1972; 47% went to the United Kingdom, 20% to Italy, and 14% to Belgium. The average valuation was 43½ cents per pound compared with 31 cents in 1972. Exports of wrought titanium (ingots and mill shapes) were up 33% from 1972 levels. Canada imported 38% of the total, the United Kingdom 23%, and France, West Germany, and Italy a total of 25%.

As a result of changes in the titanium industry product mix over the past few years import statistics for titaniferous raw materials no longer give a clear, complete picture of foreign trade. Six different materials are being imported in significant quantities: Ilmenite, rutile, Sorel slag, synthetic rutile (beneficiated ilmenite), Sorelflux, and titaniferous iron ore. There are only three T.S.U.S.A. categories for titaniferous raw materials: 601.5120 Ilmenite and ilmenite sand, 601.5140 Titanium minerals n.e.s., and 603.6200 Titanium slag. In addition, some synthetic rutile is imported under category 603.7 (Other metal-bearing materials).

In 1973, imports as reported by the Bureau of the Census, Department of Commerce, were 216,350 tons of ilmenite and ilmenite sand, 311,153 tons of titanium minerals n.e.s., and 100,327 tons of titanium slag. However, the results of a Bureau of Mines canvass showed consumption of 281,791 tons of slag in 1973, of which only 22,373 tons came from inventory.

Since all slag and the great bulk of titaniferous iron ore was imported from Canada, and since Canada was the sole source of slag and of Sorelflux, the raw monthly data for imports from Canada were analyzed. The governing parameter was the declared valuation in U.S. dollars per short ton. Entries in the $5 to $25 range were reclassified as titaniferous iron ore, which included Sorelflux and material for aggregate. Entries in the $30 to $40 range were classified as ilmenite, and those in the $40 to $65 range were classified as Sorel slag. These classifications were for Canadian imports only; data for other imports were accepted on the basis of f.o.b. prices in the country of origin.

Synthetic rutile during 1973 bore a declared valuation of $65 to $110 per ton. Some entries in this price range were noted in both the 601.5120 and the 601.5140 listings. Valuations higher than $110 were identified as natural rutile. Entries in the three categories were reclassified accordingly:

Commodity	TSUSA Categories			
	601.5120	601.5140	603.6200	Total
	(short tons)			
Ilmenite	98,262	--	--	98,262
Titaniferous iron ore	83,513	--	--	83,513
Slag	83	136,838	100,327	237,248
Rutile (natural)	11,188	161,124	--	172,312
Rutile (synthetic)	23,305	13,190	--	36,495
Total	216,351	311,152	100,327	XX

XX Not applicable.

Of the 98,262 tons of ilmenite tabulated, 28,571 tons was reported from the Bahamas, a country which has no ilmenite production. Deducting this figure pending verification leaves a total ilmenite import of 69,691 tons.

Certain shipments from Japan, India, and Australia, totaling 37,515 tons, were entered under category 603.7000. These shipments met the declared-valuation criterion for synthetic rutile; however, addition of this quantity to the synthetic rutile tabulated above would result in an import volume far in excess of known world productive capacity. Therefore, pending verification, the data will not be used.

The data of table 9 are presented in accordance with the foregoing computations.

Imports of ilmenite from Australia doubled in 1973, the increase presumably coming from the new operations in Western Australia. Imports of Sorel slag from Canada amounted to 237,000 tons, a 20% decrease from the (revised) 1972 figure. Rutile from Australia was 20% less than in 1972, but substantial quantities of synthetic rutile from Japan and India brought the total imports to 209,000 tons, 5% less than the 1972 total. A total of 54,543 tons of off-grade titaniferous iron ore entered the port district of Galveston during the year, presumably intended for use in encasing seabed petroleum pipelines in heavy aggregate.

Imports of unwrought, waste, and scrap titanium increased 59% in 1973. Of the total, 5,172 tons was sponge coming from Japan (2,937 tons); U.S.S.R. (1,628 tons); and the United Kingdom (607 tons). The Japanese material had an average declared valuation of 92.5 cents per pound; the corresponding valuation of the Soviet sponge was 77 cents per pound. France and the United Kingdom were the principal sources of 512,547 pounds of titanium ferroalloys valued at $177,917.

Imports of pigment reached a total of 60,419 tons, 30% less than in 1972, but still about 7% of total U.S. consumption.

Table 8.—U.S. exports of titanium products, by class

(Short tons and thousand dollars)

Year	Ores and concentrates		Metal and alloy sponge and scrap		Intermediate mill shapes and mill products, n.e.c.		Pigments and oxides	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1971	1,760	299	1,711	1,139	430	4,788	26,759	9,378
1972	1,802	394	3,510	2,165	562	6,265	10,335	4,882
1973	1,494	353	4,142	3,601	745	8,748	20,769	14,021

Table 9.—U.S. imports for consumption of titanium concentrates, by country [1]
(Short tons and thousand dollars)

Country	1971		1972		1973	
	Quantity	Value	Quantity	Value	Quantity	Value
Ilmenite:						
Australia	21,953	218	14,334	142	29,590	378
Canada	5,838	122	317	11	172	6
Finland	302	18	--	--	--	--
India	--	--	--	--	[2] 3,360	30
Malaysia	--	--	[2] 185	2	16,327	224
Sweden	--	--	--	--	20,242	236
Total	28,093	358	14,836	155	69,691	[3] 875
Titanium slag [4]	152,661	6,561	298,259	13,124	237,248	10,981
Rutile: [5]						
Australia	196,555	21,664	220,025	24,041	174,754	24,378
Austria [6]	--	--	22	3	--	--
Canada [6]	--	--	20	3	134	18
Denmark [6]	--	--	18	2	20	3
India	13,175	1,118	--	--	28,472	2,272
Japan	--	--	448	25	5,405	483
Malaysia [6]	--	--	--	--	23	5
Sierra Leone	18,054	1,472	--	--	--	--
Total	227,784	24,254	220,533	24,074	208,808	27,158
Titaniferous iron ore [7]	134,120	2,423	82,133	954	83,513	1,395

[1] Data adjusted by Bureau of Mines, U.S. Department of the Interior.
[2] May have been used in heavy aggregate.
[3] Data does not add to total shown because of independent rounding.
[4] All from Canada.
[5] Includes synthetic rutile.
[6] Country of transshipment rather than country of production.
[7] Includes materials consumed for purposes other than production of titanium commodities, principally heavy aggregate and steel furnace flux. All from Canada.

Table 10.—U.S. imports for consumption of unwrought titanium and waste and scrap
(Short tons and thousand dollars)

Country	1971		1972		1973	
	Quantity	Value	Quantity	Value	Quantity	Value
Austria	4	3	--	--	758	404
Canada	118	128	12	9	120	116
France	--	--	10	10	17	20
Germany, West	41	28	141	147	311	492
Italy	(1)	1	(1)	1	11	9
Japan	2,523	4,375	2,345	4,255	2,960	5,508
Netherlands	3	3	2	2	12	17
South Africa, Republic of	--	--	2	1	--	--
U.S.S.R.	214	331	1,408	2,109	1,628	2,504
United Kingdom	120	131	253	420	824	1,401
Total	3,023	5,000	4,173	6,954	6,641	10,471

[1] Less than ½ unit.

Principal suppliers were West Germany and Canada, 23% each, and the United Kingdom and France, 14% each.

Imports of synthetic rutile from all three producing nations—Australia, India, and Japan—continued during the year. Shipments were reported from both current production and inventory.

WORLD REVIEW

Australia.—It was announced in August that Australia's Federal budget for 1973–74 for the first time contained no provision for tax concessions to private companies, including mining companies. In addition the Federal Government is restricting exports of minerals by setting minimum prices.

Restrictions inspired by environmental considerations were reported to have prevented mining of about one-fourth of the known mineral sand reserves on Australia's east coast, at an estimated cost of A$300 million in exports. NL Industries' $7.5 million beach sand project in Queensland was rejected by State authorities "for environmental reasons" although rehabilitation of the land following beach sand mining is usually successful.

Elsewhere on the east coast, production slowly advanced from the low fourth quarter of 1972. Totals for the year for New South Wales and Queensland were 351,000 tons of rutile and 38,900 tons of ilmenite.

A process by which ilmenite is upgraded to rutile grade, jointly owned by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Murphyores Incorporated Pty. Ltd., was being tested jointly by Murphyores and Mitsubishi Chemical Industries, Ltd., in a pilot plant at Kurosaki, Japan. Planning began about midyear for a commercial-scale plant, using the process, to be built in Australia. Successful exploitation will permit expanded use of east coast ilmenites, which were in minimal demand for pigment production because of their chromium and vanadium content.

Mining activity along a 100-mile stretch of the Australian west coast continued at a high level during the year. Expansion of mineral sands production is proceeding from Jurien Bay to Geraldton, where proved and probable reserves exceed 130 million tons of heavy-sand products. Companies involved are Allied Eneabba Pty. Ltd., Ilmenite Pty. Ltd., A. V. Jennings Industries (Australia) Ltd., and Westcoast Rutile Pty. Ltd.

Allied Eneabba formally commissioned its 45,000-ton-per-year pilot plant on April 6. Operations at this scale apparently were successful, since in November it was announced that the company will begin construction of a 350,000-ton-per-year plant at a cost of about $12.4 million, to be fully operational by late 1975. Anticipated annual production at that time will be 200,000 tons of ilmenite and 50,000 tons of rutile. Leucoxene, zircon, monazite, and kyanite will also be produced in commercial quantities. During the pilot operation it became clear that dredging the deposit from a moving dredge pond was unsatisfactory; future mining will be conducted by dry methods. For the time being, exports will be made from the port of Geraldton, but it is possible that the company will build port facilities nearer the mining operation. A narrow-gage railway is also contemplated.

The litigation concerning 22 mineral claims in the Eneabba beach sands was decided in favor of Western Titanium N.L. A final appeal to the Privy Council in London is being considered. If the decision stands, Allied Eneabba's resources will be reduced to about 8 million tons of mineral concentrates, 0.75 million of which is rutile. However, Eneabba contemplates no change in its plans or the scale of operations.

A. V. Jennings Industries (Australia) Ltd., began processing its sands on a pilot scale in March. Construction of a $13 million full-scale plant is underway, to be operational in 1974 at the annual rate of 120,000 tons of ilmenite, 35,000 tons of leucoxene, 40,000 tons of rutile, and some zircon.

West Coast Rutile Ltd., a joint-venture company, one-third held by Mining Corp. of Australia Ltd. and two-thirds by Kamilaroi Mines, Ltd., completed a feasibility study on its 54 claims at Jurien Bay. Exploration indicates 3.2 million tons of heavy sands. A potential annual production scale was estimated at 150,000 tons of ilmenite, 19,000 tons of leucoxene, 25,000 tons of rutile, and some zircon and kyanite.

South of Perth, Westralian Sands, Ltd., established a new open pit mine in the Tutunup area, from which most of Westralian's production was coming at the yearend. Mining in the area between Yoganup and the Capel River ceased about midyear. Exploration further northward was undertaken in a joint venture with Tioxide Australia Pty. Westralian's production in the fiscal year ending June 30 exceeded 230,000 tons, 85% of it ilmenite.

Project Mining Corp. drilled nine claims at Hardy Inlet, near Augusta, and has an indicated reserve of 1 million tons of ilmenite. The company will initiate mining as soon as environmental clearance is obtained.

Western Titanium N.L. continued construction of its ilmenite upgrading plant at Capel, near Bunbury. The plant will produce a synthetic rutile of 94% TiO_2 grade and is expected onstream in April 1974. The company reports production of 43,553 tons of upgraded ilmenite between February 1, 1969, and June 30, 1973.

Brazil.—Cia. Vale do Rio Doce and two Japanese companies, Ishihara Sangyo Kaisha, Ltd., and C. Itoh, Ltd., signed an agreement to evaluate anatase resources in a carbonatite formation near Araxá, Minas Gerais. The Departamento Nacional de Produçáo Mineral (DNPM) evaluated reserves at 1,600 million tons of ore containing 10% TiO_2. The same two Japanese companies also signed an agreement with Cia. Brasileira de Tecnologia Nuclear to appraise the possibility of exploiting ilmenite beach sand resources in Espírito Santo to blend with the anatase as feed for a titania pigment plant. Earliest possible target date will be 1976.

Canada.—In December, Quebec Iron & Titanium Corp. announced plans to expand throughput of ilmenite ore at its Sorel, Quebec, plant to 2.2 million tons. The expansion will cost $8.8 million. An additional $2.6 million will be invested in pollution abatement at Sorel. Project completion is scheduled for mid-1975. Canadian pigment production was reported at 46,318 tons for the year.

India.—Recent estimates of ilmenite reserves and resources in India were placed at 356 million tons by the Geological Survey of India; by extension, reserves of rutile, monazite, and other associated minerals also are substantial. Indian Rare Earths, Ltd., a government corporation, is the sole beach sand mining entity. Annual capacity of the two company beneficiation plants, one at Manavalakurichi, Tamil Nadu, the other at Chavara, Kerala, totals 175,000 tons of ilmenite, 7,700 tons of rutile, and some zircon, monazite, garnet, and sillimanite. A 30% expansion at Chavara, underway during the year, will bring total ilmenite capacity to more than 200,000 tons.

The synthetic rutile facility of Dhrangadhra Chemical Works, Ltd., based on the Benilite process and obtaining its hydro-

Table 11.—Titanium: World production of concentrates (ilmenite, rutile, and titaniferous slag), by country

(Short tons)

Country [1]	1971	1972	1973 [p]
Ilmenite: [2]			
Australia [3]	914,116	781,324	781,493
Brazil [4]	10,906	3,849	4,599
Finland	153,772	164,795	175,267
India	72,752	78,774	[e] 79,000
Japan	2,619	2,331	[e] 2,400
Malaysia [5]	171,941	167,743	[e] 167,800
Norway	707,198	670,723	803,610
Portugal	981	829	[e] 880
Spain	26,033	25,295	26,088
Sri Lanka	102,396	90,944	[e] 93,700
United States [6]	683,075	681,644	804,355
Total [2]	[r] 2,845,789	2,668,251	2,939,192
Rutile:			
Australia	404,233	349,899	361,422
Brazil [3]	129	454	46
India	3,210	3,379	[e] 3,400
Sierra Leona	13,153	--	--
Sri Lanka [e]	3,100	[r] 2,800	2,900
Total	[r] 423,825	356,532	367,768
Titaniferous slag:			
Canada [7]	853,000	920,400	942,700
Japan	6,097	3,668	4,690
Total	859,097	924,068	947,390

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition to the countries listed, the U.S.S.R. also produces titanium concentrates, but available information is inadequate to make reliable estimates of output levels.

[2] Titaniferous slag production in Canada and Japan, reported under this heading in previous years, is reported separately in this edition. Ilmenite produced in Canada goes almost entirely into slag production; separate figures are not available.

[3] Includes leucoxene.

[4] Production of Comissão Nacional de Energia Nuclear only.

[5] Exports.

[6] Includes a mixed product containing ilmenite, leucoxene, and rutile.

[7] Contains 70% to 71% TiO_2.

chloric acid from a source adjacent to its location at Sahupuram, Tamil Nadu, was reported to have exported 38,000 tons of product to the United States up to March 31, 1973. The synthetic rutile contains 90%–92% TiO_2, 0.25% V_2O_5, and 0.2% Cr_2O_3.

Political difficulties have delayed the authorization to construct a titanium products complex at Chavara, issued originally to Ballarpur Paper and Strawboard Mills in 1968.

Italy.—The sulfate-process pigment plant of Montecatini Edison S.p.A. (Montedison) at Scarlino was the target of much criticism because of its practice of disposing of waste by dumping at sea. Quantities dumped ranged from 2,500 to 3,000 tons per day. Montedison sought temporary solutions by converting a portion of its effluent to ferrous oxide and reclaiming sulfuric acid, and also by disposing of its waste at depths below the normal habitat of most marine life. However, in September a local magistrate ordered seizure of the two ships used to move waste to the dumping grounds. As a long-range solution, Montedison was committed to adopt a process developed by New Jersey Zinc Co. to separate out ferrous sulfate and concentrate the remaining acid sufficiently for reuse. However, the recovery plant will probably be operative no earlier than mid-1976; meanwhile resumption of operations depends on further court action.

Montedison also contracted to build a 100,000-ton-per-year pigment plant in the U.S.S.R., payment to be received in the form of pigment produced at the plant.

Japan.—Ishihara Sangyo Kaisha, Ltd., reported that experience with its synthetic rutile product in making chloride-process titania pigment has been favorable. Kerr-McGee Chemical Corp. uses some of Ishihara's material in the feedstock to its pigment plant at Hamilton, Miss.

Following environmentally-induced shutdowns of pigment plants during 1972, supplies declined to less than domestic demand. As a result, Japan had no pigment available for export, and was offering to import from producing nations at prices somewhat in excess of those current in the United States. The shortfall of Japanese production was estimated at 11,000 tons for the year.

Japanese companies produced 7,173 tons of sponge and 4,690 tons of slag during 1973. The nominal capacity of Japan's three sponge producers—Osaka Titanium Co., Ltd., Toho Titanium Co., Ltd., and Nippon Soda Co.—is about 14,500 tons. The industry was reported to be in full-capacity production at yearend.

Malaysia.—Pacific Tin Consolidated Corp. was reported in September to be readying a plant to make an ilmenite concentrate as a byproduct of its tin recovery operations.

The Malaysian Titanium Corp. has contracted with Woodall-Duckham, Ltd., of the United Kingdom, for construction of an ilmenite upgrading facility, based on the Benilite process, at Ipoh, Perak. Capacity is stated to be 65,000 tons of product per year. The plant will cost $9 million, 35% of which will be supplied by an as-yet-unnamed company in the United States.

Mexico.—The 23,000-ton sulfate-process pigment plant of Pigmentos y Productos Quimicos, S.A. de C.V., at Altamira, Tamaulipas, was being replaced with a chloride-process plant of 35,000-ton capacity. A chlorine-caustic soda facility to supply the necessary chlorine was also approved for construction at the site. The cost of both plants is estimated at $8 million.

Norway.—Begun in 1972, current expansion of mining and beneficiating operations of Titania A/S, an NL Industries, Inc., subsidiary, at Hauge-i-Dalane will permit production of over 1 million tons of ilmenite flotation concentrate annually. The scale-up was essentially completed late in 1973. The ilmenite product contains about 45% titanium dioxide, 46.5% iron oxides, 0.16% vanadium pentoxide, and a maximum of 0.075% chromous oxide. The plant also produces annually 40,000 tons of magnetite at 65% iron and 10,000 tons of a sulfide concentrate containing over 4% nickel and over 2% copper.

Poland.—In May, the Polish Government placed contracts with Kronos Titan GmbH, Leverkusen, and Krupp Chemieanlagenbau, Essen, West Germany, for construction of a sulfate process pigment plant. The intended annual capacity will be 40,000 tons. The plant is to be built near Stettin, will cost $25 million, is expected onstream in mid-1976, and will use Norwegian ilmenite.

Sierra Leone.—Ownership of the 60% share of Sierra Rutile, Ltd., was transferred from Armco Steel Corp. to Bethlehem Steel Corp. during the year. Engineering studies, begun in 1972, continued during 1973, and in October Sierra Rutile began to staff key positions. A 100-ton-per-day pilot plant was under construction. Full-scale production at 20,000 tons of feed per day is expected by mid-1975; at this scale, 200 tons of rutile per day may be produced.

In September, the Bayer-Preussag Mining Co. resumed operations at the adjacent Bonthe and Moyamba mines, on a limited scale.

Spain.—Pigment from the 30,000-ton-per-year sulfate-process plant under construction at Huelva by a joint venture of Union Explosivos Rio Tinto (55%) and British Titan, Ltd. (45%), was expected to come on the market in 1975. The cost of the facility was estimated at $20 million. Some imports of ilmenite will be necessary at first. New plans called for expansion to 60,000 tons annually by 1976 and 100,000 tons by 1978. Meanwhile du Pont, which early in the year had been considering Spain as the site of a 100,000-ton-per-year plant, abandoned its interest about midyear.

Taiwan.—Woodall-Duckham, Ltd., undertook construction of a 30,000-ton-per-year synthetic rutile plant for Taiwan Alkali Co. at Kaohsiung. It will use the Benilite process, which is reputed to be pollution free. The sources of the feedstock and the grade of the product were not specified. Laporte Industries, Ltd., reportedly has signed a forward contract for delivery of 2,000–2,500 tons of the synthetic rutile.

U.S.S.R.—Reports indicated that a titaniferous slag containing 83% titanium dioxide is being made at Zaporozhe. The slag is chlorinated; the tetrachloride is purified and fed to Kroll-type reaction furnaces. New sponge-production facilities were said to be under construction during the year.

Yugoslavia.—A sulfate-process pigment plant of 27,000 tons annual capacity was opened June 30 at Celje. The plant, jointly owned by a Yugoslav and an East German corporation in a 51:49 ratio, was to export part of its production to East Germany. On July 7 production at the $31 million plant was halted by fire. Resumption of full production is expected early in 1974.

TECHNOLOGY

Mineral Deposits, Ltd., an Australian company mining rutile and zircon at Seven Mile Beach, New South Wales, installed Reichert cone concentrators as roughing units in its wet separation plant. A quite low operating cost is claimed. Total power consumption is quoted at 1.36 kilowatt-hours per ton of sand mined.[2]

Since silicates in certain proportions interfere with the effective chlorination of ilmenite in fluidized bed equipment, a mineral-dressing procedure has been devised by which the silicates may be separated on the basis of their selective wetting by an immiscible liquid and consequent spherical agglomeration.[3]

A method for using sulfate-process pigment plant effluent constructively, thereby solving a waste disposal problem, is being tried in Western Australia. Laporte Industries, Ltd., has contracted with Hancock & Wright for the latter to locate part of its manganese dioxide pilot plant at Laporte's Bunbury pigment facility. Treatment of lean manganese ore with the ferrous sulfate wastes permits subsequent extraction of high-grade manganese dioxide; ferric hydroxide becomes the waste product and is relatively less toxic and easier to dispose of than the sulfates.[4]

In spite of the inability of technical observers to find adverse effects in the oceanic dumping areas, pressure against discharging of sulfate-process waste at sea is increasing; the practice soon may no longer be permitted.[5] Three courses are open to the sulfate-process pigment producers: (1) Something useful may be made from the effluent; (2) the effluent

[2] World Mining. Mining and Concentrating Beach Sands. V. 26, No. 11, October 1973, pp. 49–50.

[3] Sparks, B. D., and R. H. T. Wong. Selective Spherical Agglomeration of Ilmenite Concentrates. Can. Min. & Met. Bull., v. 66, No. 729, January 1973, pp. 73–77.

[4] Industrial Minerals. MnO_2: TiO_2's New Friend? No. 74, November 1973, p. 29.

[5] Chemical Week. Heavy Going Ahead for Waste Discharging at Sea. V. 112, No. 26, June 27, 1973, pp. 45–47.

can be treated to separate something—most probably sulfuric acid—which can be recycled to the process; or (3) the effluent can be filtered and otherwise treated to make a solid having no pollution potential. Gypsum, copperas, iron powders and ferric oxide, and recycle sulfuric acid are most commonly mentioned as end products of effluent treatment.

Ishihara Sangyo Kaisha, Ltd., makes synthetic rutile by treating partially reduced ilmenite with sulfuric acid. The original plant reached its 27,000-ton capacity by the end of 1971, expanding to 40,000 tons by the end of 1973.[6] The product has been used experimentally as feed to chlorinators making titanium tetrachloride for conversion to titanium sponge. Toho Titanium Ltd., reported satisfactory results and intends using the material commercially.[7]

Basing its work on earlier studies by The Dow Chemical Co. and the U.S. Bureau of Mines, Dow and Howmet Corp. are jointly operating a pilot plant to produce, by fused-salt electrolysis, a titanium metal which will be competitive with Kroll-process sponge. The work is being done at Howmet's research center in Whitehall, Mich. Advantages claimed for the process include smaller capital investment, substantially lower energy needs, fewer pollution control problems, and a higher quality product. Some of the metal produced was converted to ingot, which has obtained some consumer acceptance.[8]

The Wyatt division of U.S. Industries Inc., developed and successfully used a technique by which large sections of titanium metal can be welded in the field. A shield over the welding area permits maintenance of a protective gas atmosphere.[9]

Airco, Inc., developed a method for converting light titanium 6/4 alloy scrap to a usable secondary alloy. The scrap, formerly wasted, now is cleaned and refined in a hearth-type furnace, where the aluminum and oxygen contents are decreased. The resultant metal has good strength and ductility. Initially Airco will produce a million pounds annually from home scrap. Probable applications will be in process industries hardware, where corrosion resistance at ambient or moderately elevated temperatures is desired.[10]

A new titanium alloy reportedly was developed by a defense contractor working with the U.S. Air Force. Called Ti17, it contains 5% aluminum, 4% each chromium and molybdenum, 2% each tin and zirconium, and small quantities of iron, manganese, and copper. It is said to be 25% stronger than titanium 6/4 and more resistant to crack growth.[11]

Made necessary by greatly increased mining of ilmenite in Western Australia, a method for determining the chromium content of ilmenite by atomic absorption spectrometry was developed. Sensitivity was in the area of 0.03% to 0.10% chromium.[12]

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[6] Kataoka, S., and S. Yamada. Acid Leaching Upgrades Ilmenite to Synthetic Rutile. Chem. Eng., v. 80, No. 7, Mar. 19, 1973, pp. 92–93.
[7] Metal Bulletin. Toho to Use Synthetic Rutile. No. 5778, Feb. 23, 1973, p. 14.
[8] Metals Week. Dow and Howmet in Joint Titanium Venture. V. 44, No. 20, May 14, 1973, p. 10.
[9] Iron Age. Process Permits Field Welding of Titanium Plate. V. 211, No. 3, Jan. 18, 1973, p. 27.
[10] Iron Age. Process Converts Ti Scrap. V. 211, No. 20, May 17, 1973, p. 27.
[11] Titanium News. New Ti Alloy to Compete With 6/4? V. 4, No. 1, winter 1973, p. 2.
[12] O'Shaughnessy, P. T. Determination of Trace Levels of Chromium in Ilmenite by Atomic Absorption Spectrometry. Anal. Chem., v. 45, No. 11, September 1973, pp. 1946–1947.

Tungsten

By Richard F. Stevens, Jr.[1]

Although domestic tungsten production, as measured by mine shipments, increased slightly in 1973, mine output decreased 7% to 7.6 million pounds. Most of this material was obtained from two domestic operations, one in California and one in Colorado, which were worked continuously throughout the year. Concentrate consumption rose 9% to 15.4 million pounds. Imports for consumption of tungsten concentrate almost doubled in 1973 and totaled 10.6 million pounds, the highest level in 16 years.

During 1973, the reported price of shipped tungsten concentrate, f.o.b. mines and custom mills, increased 5% and averaged $43 per short ton unit; the quoted European price averaged about $40 per short ton unit (about $44 per short ton unit with U.S. import tariff added).

No tungsten concentrate from Government stockpiles was sold until early in October 1973 when the General Services Administration (GSA) program was revised to a monthly sealed-bid basis. Under this program, almost 1.5 million pounds of tungsten in concentrate was awarded for domestic use (81%) and for export (19%).

Legislation and Government Programs.—On April 12, 1973, the Office of Emergency Preparedness (OEP) significantly reduced stockpile objectives and subobjectives for tungsten and tungsten-bearing materials as indicated by the following tabulation, in pounds of contained tungsten:

Material	Old objective	New objective
Tungsten ore and concentrate	55,655,500	4,234,000
Tungsten carbide powder	1,900,000	--
Tungsten metal powder, carbon reduced	547,000	--
Tungsten metal powder, hydrogen reduced	1,200,000	--

[1] Physical scientist, Division of Ferrous Metals—Mineral Supply.

Table 1.—Salient tungsten statistics

(Thousand pounds of contained tungsten and thousand dollars)

	1969	1970	1971	1972	1973
United States:					
Concentrate:					
Production	7,805	9,625	6,900	8,150	7,575
Shipments	7,910	9,312	6,827	7,045	7,059
Value	18,770	23,790	20,184	18,104	19,154
Consumption	13,053	16,700	11,622	14,107	15,386
Releases from Government stocks	38,314	15,066	1,381	3	1,498
Exports [1]	7,151	19,470	2,006	95	90
Imports, general	1,534	1,299	577	5,898	10,785
Imports from consumption	1,503	1,284	418	5,739	10,552
Stocks, Dec. 31:					
Producers	519	787	863	1,966	225
Consumers	1,066	1,467	2,657	2,229	1,446
Employment [2]	570	605	470	510	535
Primary products:					
Production	13,334	17,605	11,730	14,090	17,096
Consumption	16,056	15,352	11,159	13,296	17,984
Stocks, Dec. 31:					
Producers	3,392	4,569	3,722	4,680	3,523
Consumers	1,778	2,698	2,541	2,121	2,051
World: Concentrate:					
Production	71,754	71,360	r 78,055	r 84,470	85,320
Consumption	76,650	85,638	r 68,413	r 76,583	84,504

r Revised.
[1] Estimated tungsten content.
[2] Estimated number of persons at mines and mills, at yearend.

Also in April, "Omnibus" bills (H.R. 7153 and S. 1849) were submitted to the Congress to obtain authorization for disposal of these additional excess tungsten materials. This proposed legislation was reviewed by the American Mining Congress, a trade association of the domestic mining industry, in a detailed report.[2] Another bill (H.R. 1257) was reintroduced early in the year to temporarily suspend the tariff on tungsten concentrate and on other materials in chief value of tungsten (primarily synthetic scheelite). At yearend none of these bills had been acted upon by the Congress.

Under the President's Reorganization Plan No. 1 of 1973, issued January 26, 1973, the stockpile functions of OEP were scheduled for assumption by GSA at the beginning of the new Fiscal Year (July 1, 1973) and Executive Order 11725, issued June 29, 1973, created the Office of Preparedness (OP) within GSA to handle the former OEP stockpile operations.

Following the first half of 1973, GSA ceased offering excess tungsten concentrate for sale under a two-phase program that (1) offered tungsten as a "shelf-sale" item at $55 per short ton unit restricted to domestic consumption and (2) offered tungsten for export on a monthly sealed-bid basis. After reevaluating the tungsten market, GSA initiated monthly sealed-bid offerings in September at a rate not to exceed 6 million pounds of tungsten per year. Under this new program (ORES–199), approximately 80% of the sales was allocated for domestic use; the balance was for export. Almost 1.5 million pounds in concentrate was sold during 1973.

During the year, the price paid, excluding duty (ex-duty), for stockpiled tungsten concentrate for domestic use ranged from $40.65 to $48.32 per short ton unit. The price paid, ex-duty, for stockpiled concentrate for export ranged from $40.67 to $47.27 per short ton unit.

In addition, 51,000 pounds of contained tungsten in excess stockpiled concentrate was assigned for Government use in December.

Table 2.—U.S. Government tungsten stockpile materials inventories and objectives

(Thousand pounds, tungsten content)

Material	Objective	Inventory by program Dec. 31, 1973: National (strategic) stockpile	DPA inventory	Supplemental stockpile	Total
Tungsten concentrate:					
Stockpile grade	4,234	72,319	4,466	3,304	80,089
Nonstockpile grade	--	40,083	509	1,153	41,745
Total inventory	--	112,402	4,975	4,457	121,834
Ferrotungsten	--	2,141	--	--	2,141
Tungsten metal powder, hydrogen reduced	--	1,219	--	--	1,219
Tungsten metal powder, carbon reduced	--	717	--	--	717
Tungsten carbide powder	--	953	--	1,080	2,033

DOMESTIC PRODUCTION

Domestic mine production fell 7% and totaled 7.6 million pounds of tungsten during the year, but mine shipments increased only slightly to less than 7.1 million pounds. Although 28 mines in eight Western States reported production and 25 mines reported concentrate shipments, only two mines operated continuously throughout 1973: The Pine Creek mine and mill of the Mining and Metals Division, Union Carbide Corp., located northwest of Bishop, Calif.; and the Climax mine and mill of Climax Molybdenum Co., a division of American Metal Climax, Inc. (AMAX), near Leadville, Colo. The major mineral value recovered at Pine Creek continued to be tungsten along with minor amounts of byproduct molybdenum, copper, silver, and gold. This material was processed on a "straight through" basis to produce ammonium paratungstate (APT), an intermediate processed form of tungsten suitable for ready conversion to tungsten metal powder.

[2] American Mining Congress. The Stockpile Problem. Washington, D.C., June 1973, 20 pp.

At Climax, the major mineral value recovered was molybdenum. Concentrates of tungsten, tin, and pyrite were recovered as coproducts and were largely dependent upon the rate of molybdenum producton.

In North Carolina, the Tungsten Queen mine and mill of Ranchers Exploration & Development Corp. near Townsville remained closed and on "standby" status throughout the year.

Table 3.—Tungsten concentrate shipped from mines in the United States

Year	Quantity			Reported value f.o.b. mine [1]		
	Short tons 60% WO_3 basis [2]	Short ton units WO_3 [3]	Tungsten content (thousand pounds)	Total (thousands)	Average per unit of WO_3	Average per pound of tungsten
1969	8,312	498,706	7,910	$18,770	$37.64	$2.37
1970	9,785	587,088	9,312	23,790	40.52	2.55
1971	7,173	430,427	6,827	20,184	46.89	2.96
1972	7,401	444,145	7,045	18,104	40.77	2.56
1973	7,418	445,051	7,059	19,154	43.04	2.71

[1] Values apply to finished concentrate and are in some instances f.o.b. custom mill.
[2] A short ton of 60% tungsten trioxide (WO_3) contains 951.72 pounds of tungsten.
[3] A short ton unit equals 20 pounds of tungsten trioxide (WO_3) and contains 15.862 pounds of tungsten.

CONSUMPTION AND USES

The major domestic companies that were engaged in tungsten processing operations during 1973 are listed in table 5.

The application of tungsten in cutting and wear-resistant materials, primarily as tungsten carbide, increased and continued to represent the major form of tungsten product consumption. This use accounted for 56% of the total product consumption, which rose 35% to almost 18.0 million pounds of tungsten in 1973. Other major end-use categories during the year were as follows: Mill products (15%), specialty tool steels (11%), and welding and hardfacing materials (7%).

During 1973, the consumption distribution of intermediate tungsten products used to make end-use items was as follows: Tungsten carbide (including cemented, crushed, and cast), 43%; tungsten metal powder (including carbon- and hydrogen-reduced), 35%; and chemicals (including scheelite and scrap for direct addition to steel melts) and ferrotungsten, 11% each.

Two comprehensive reports based on information supplied by industry and Government specialists were published during the year.[3] These reports analyzed the tungsten industry and projected anticipated supply-demand relationships through 1987.

Micrograin tungsten carbide cutting tools were used in more high-temperature applications where conventional carbides chip and high-speed steels fail or soften. To eliminate voids, cemented tungsten carbides were produced by hot isostatic pressing.

A study to develop new less expensive, man-made cutting tools was continued by the General Electric Co. (GE) under funding sponsored by the Advance Research Projects Agency (ARPA), Washington, D.C. This study, conducted at GE's research laboratory in Schenectady, N.Y., was monitored by the Air Force Materials Laboratory (AFML) at Wright-Paterson AFB near Dayton, Ohio.

Several special review articles were published during the year that evaluated the application of tungsten metal in high-temperature nuclear applications, evaluated tungsten carbide cutting tools, and reviewed the current and future tungsten supply-demand situation.[4]

[3] National Materials Advisory Board. Trends in Usage of Tungsten. NMAB-309, July 1973, 106 pp.; available from the National Technical Information Service, Springfield, Va., PB 223 716.
Slater, D. Tungsten: Mineral Dossier No. 5. Inst. Geol. Sci. (London), 1973, 43 pp.
[4] American Metal Market. Cutting Tools Report. V. 80, No. 39, Feb. 26, 1973, pp. 7–21.
———. High-Temperature Alloys. V. 80, No. 154, Sec. 2, Aug. 8, 1973, 20 pp.
———. Metal Traders Section. V. 80, No. 115, Sec. 2, June 13, 1973, 12 pp.
———. Metals For Nuclear Energy. V. 80, No. 120, Sec. 2, June 20, 1973, 8 pp.
———. Molybdenum Section. V. 80, No. 159, Sec. 2, Aug. 15, 1973, 8 pp.
———. Powder Metals. V. 80, No. 110, Sec. 2, June 6, 1973, 8 pp.
———. Space Age Metals Report. V. 80, No. 49, Mar. 12, 1973, pp. 19–30.
———. Tool and Die. V. 81, No. 14, Jan. 21, 1974, pp. 17–20.
———. Tool and Die Report. V. 80, No. 15, Jan. 22, 1973, pp. 13–28.
———. Tungsten Section. V. 80, No. 27, Sec. 2, Feb. 7, 1973, 16 pp.
———. Vacuum Metallurgy. V. 80, No. 125, Sec. 2, June 27, 1973, 8 pp.

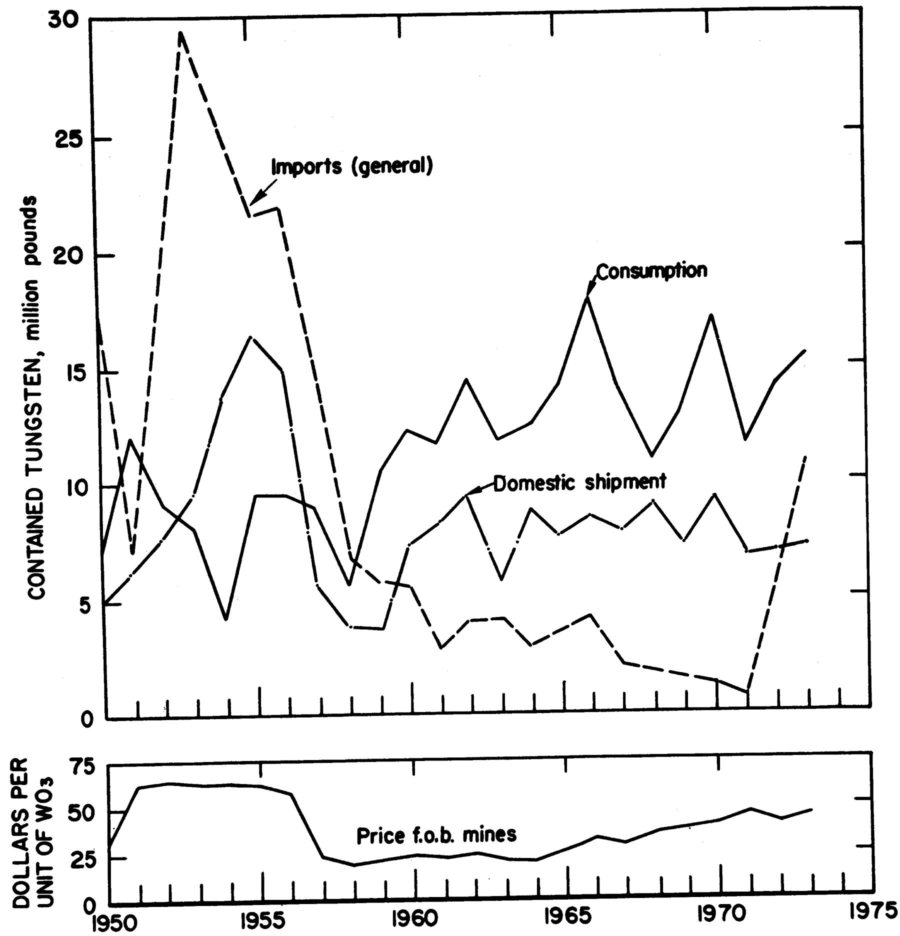

Figure 1.—Domestic shipments, imports, consumption, and average price of tungsten ore and concentrate.

Table 4.—Production, shipments, and stocks of tungsten products in the United States
(Thousand pounds of contained tungsten)

	Hydrogen- and carbon-reduced metal powder	Tungsten carbide powder: Made from metal powder	Tungsten carbide powder: Crushed and crystal-line	Chemi-cals [1]	Other [2]	Total
1972:						
Gross production during year	9,529	5,062	1,949	13,461	1,000	31,001
Used to make other products listed here	6,220	--	27	10,664	--	16,911
Net production	3,309	5,062	1,922	2,797	1,000	14,090
Shipments [3]	7,163	5,016	2,407	7,664	1,031	23,281
Producer stocks, Dec. 31	1,921	295	465	1,852	147	4,680
1973:						
Gross production during year	12,420	7,798	3,242	4,688	1,520	29,668
Used to make other products listed here	8,405	--	60	3,945	162	12,572
Net production	4,015	7,798	3,182	743	1,358	17,096
Shipments [3]	9,727	7,758	4,461	918	1,320	24,184
Producer stocks, Dec. 31	1,925	418	619	254	307	3,523

[1] Data for 1973 not directly comparable to 1972. In 1973 ammonium paratungstate (APT) data was separately reported as equivalent concentrate and was removed from the "Chemicals" category.
[2] Includes ferrotungsten, scheelite (produced from scrap), nickel-tungsten, self-reducing oxide, and pellets.
[3] Includes quantities consumed by producing firms for manufacture of products not listed here.

Table 5.—Major U.S. producers of tungsten concentrate and principal tungsten processors in 1973

Company	Location of mine, mill or processing plant
Producers of tungsten concentrate:	
Climax Molybdenum Co., a subsidiary of AMAX	Climax, Colo.
Ranchers Exploration & Development Corp.[1]	Townsville, N.C.
Rawhide Mining Co	Fallon, Nev.
Transcon Corp	Mountain City, Nev.
Union Carbide Corp. (UCC), Mining & Metals Div.[2]	Bishop, Calif.
Processors of tungsten: [3]	
Adamas Carbide Corp	Kenilworth, N.J.
Fansteel Inc	North Chicago, Ill.
General Electric Co	Cleveland and Euclid, Ohio, and Detroit, Mich.
GTE Sylvania, Inc., a subsidiary of General Telephone & Electronics Corp	Towanda, Pa.
Kennametal, Inc	Latrobe, Pa., and Fallon, Nev.
Li Tungsten Corp	Glen Cove, N.Y.
Molybdenum Corp. of America (Molycorp)	Washington and York, Pa.
Teledyne Firth Sterling	McKeesport, Pa.
Teledyne Wah Chang Huntsville	Huntsville, Ala.
Union Carbide Corp., Mining & Metals Division	Niagara Falls, N.Y.
Westinghouse Electric Corp	Bloomfield, N.J.

[1] On standby status.
[2] At its Pine Creek mine and mill in California, UCC processes scheelite ore "straight through" to APT.
[3] Major consumers of tungsten concentrate and APT.

STOCKS

Stocks of tungsten concentrate held at domestic mines fell substantially at yearend and were 83% less than in 1972, whereas tungsten concentrate stocks held by consumers decreased 35% during the year. Industry stocks of intermediate tungsten products increased as indicated in tables 1, 4, and 6. Data on domestic stocks of tungsten concentrate held by dealers were not available.

Table 6.—Consumption and stocks of tungsten products in the United States, by end use

(Thousand pounds of contained tungsten)

	Ferro-tungsten [1]	Tungsten metal powder [2]	Tungsten carbide powder	Other tungsten materials [3]	Total
1972:					
Steel:					
Stainless and heat resisting	105	W	--	68	173
Alloy	110	W	--	47	157
Tool	865	W	--	586	1,451
Cast irons	2	--	--	12	14
Superalloys	96	141	W	192	429
Alloys (exclude steels and superalloys):					
Cutting and wear resistant materials	W	1,394	5,017	246	6,657
Other alloys [4]	55	698	353	111	1,217
Mill products made from metal powder	W	2,523	2	--	2,525
Chemicals and ceramics	--	--	1	178	179
Miscellaneous and unspecified	5	368	120	1	494
Total [5]	1,238	5,124	5,493	1,441	13,296
Consumer stocks Dec. 31, 1972	289	650	716	466	2,121
1973:					
Steel:					
Stainless and heat resisting	134	W	--	77	211
Alloy	128	W	--	225	353
Tool	1,474	W	--	541	2,015
Cast irons	W	--	--	6	6
Superalloys	152	136	W	318	606
Alloys (exclude steels and superalloys):					
Cutting and wear resistant materials	W	2,546	7,141	313	10,000
Other alloys [4]	71	756	340	118	1,285
Mill products made from metal powder	W	2,660	W	--	2,660
Chemical and ceramic uses	--	--	W	444	444
Miscellaneous and unspecified	5	125	273	1	404
Total [5]	1,964	6,223	7,754	2,043	17,984
Consumer stocks Dec. 31, 1973	340	427	866	418	2,051

W Withheld to avoid disclosing individual company confidential data, included in "Miscellaneous and unspecified."

[1] Includes melting base self-reducing tungsten.

[2] Includes both carbon-reduced and hydrogen-reduced tungsten metal powder.

[3] Includes tungsten chemicals natural and synthetic scheelite, tungsten scrap and other.

[4] Includes welding and hard-facing rods and materials and nonferrous alloys.

[5] Data may not add to totals shown because of individual rounding.

PRICES AND SPECIFICATIONS

During 1973 the average value of tungsten concentrate shipped from domestic mines as reported to the Bureau of Mines, increased 6% to $43.04 per short ton unit of WO_3. Although there were no Government stockpile sales during the first half of the year, the quoted domestic price (nominal) of tungsten concentrate during this period continued to be $55 per short ton unit, which reflected the GSA shelf price. Tungsten concentrate was purchased from GSA during the last quarter of 1973 at prices, ex-duty, ranging from $40.65 to $48.32 per short ton unit.

As quoted in the Metal Bulletin (London) and in Metals Week the European price of tungsten concentrate, shown in table 7, increased throughout the year from a low in January of £15.70 per metric ton unit (about $33.44 per short ton unit depending upon the prevailing rate of currency exchange) to a high of £22.20 per metric ton unit (about $49.03 per short ton unit) in November.

The price of metallurgical-grade APT, delivered to contract customers, was frozen at $50.50 per short ton unit during the year. A small amount of catalytic-grade APT and "Blue Oxide" was sold during 1973 at a frozen price of $53 per short ton unit. A conversion fee of about $11 per short ton unit was charged for "toll" processing tungsten concentrate to APT at a recovery of about 96%.

In January 1974, the price of metallurgical-grade APT was increased 24% to $62.50 per short ton unit. The price of catalytic-grade APT was increased to $65 per short ton unit in January, but the "toll" conversion fee remained unchanged.

The quoted price of carbon-reduced tungsten metal powder, as reported in

Metals Week, f.o.b. shipping point, was unchanged during the year at $4.50 per pound of contained tungsten in 1,000-pound lots. The price of hydrogen-reduced tungsten metal powder (99.99% purity), f.o.b. shipping point, as quoted in Metals Week, dropped to a range of $4.97 to $6.70 per pound of tungsten in 1973. Within this range, the price was primarily dependent upon the tungsten powder particle size (Fisher number).

The quoted price of low-molybdenum-containing ferrotungsten in lots of 5,000 pounds or more, ¼-inch lump, packed, f.o.b. destination, continental United States, 70% to 80% tungsten, remained unchanged at $4.60 per pound of tungsten during 1973. The quoted price of UCAR, the special high-purity ferrotungsten produced by Union Carbide Corp. at its Niagara Falls, N.Y., plant, 90% tungsten, was $3.98 per pound of contained tungsten during the year. The U.S. dealer price of ferrotungsten during 1973, as quoted in Metals Week, remained unchanged at $4.50 (nominal) per pound of tungsten.

Although not quoted, the price of scheelite concentrate (calcium tungstate) for direct addition to steel melts was believed to be comparable with data reported in table 7.

Table 7.—Monthly price quotations of tungsten concentrate in 1973

Month	Wolfram and scheelite London market, pounds sterling per metric ton unit of WO_3, 65% basis		Equivalent quotations, dollars per short ton unit of WO_3, 65% basis [1]		
	Low	High	Low	High	Average [2]
January	£15.70	£16.60	$33.44	$35.55	$34.47
February	15.70	16.95	33.99	37.84	35.72
March	16.50	18.75	37.42	42.08	40.06
April	18.30	19.15	41.21	43.19	42.18
May	17.10	19.15	39.50	43.25	41.34
June	16.00	17.50	37.35	40.74	40.00
July	15.70	17.25	36.24	39.65	38.03
August	17.10	17.90	38.94	40.16	39.48
September	17.60	18.75	39.23	41.18	40.46
October	18.25	19.80	40.06	43.86	41.80
November	19.50	22.20	43.07	49.03	44.80
December	20.50	22.00	43.52	46.17	44.68

[1] Equivalent high and low quotations as reported by Metals Week; price dependent upon the prevailing rate of exchange.
[2] Arithmetic average of weekly quotations. Equivalent 1973 average price $40.25; duty $3.97, equivalent price, duty paid, $44.22 per short ton unit.

FOREIGN TRADE

Exports.—All exports of tungsten concentrate in 1973, which decreased 5% compared with that of 1972, represented excess material purchased from GSA stockpiles. Exports of ferrotungsten fell 40%, but exports of APT rose by a factor of four during the year. Exports of mixed tungsten carbides, primarily to Japan (30%) and Canada (28%), decreased 31% during 1973.

Exports of unwrought tungsten metal and alloy in crude form, waste, and scrap increased 68% in 1973 to 672,773 pounds, gross weight, valued at $1,017,164, and were shipped primarily to West Germany (48%), the Netherlands (25%), Canada (15%), and Belgium-Luxembourg (9%). Tungsten and tungsten alloy powder exports fell 31% during the year to 356,954 pounds gross weight, value at $2,316,935. This material was exported primarily to Japan (30%), Canada (28%), West Germany (13%), Belgium-Luxembourg (8%), and Israel (7%).

Exports of tungsten and tungsten alloy wire almost doubled in 1973 to 224,750 pounds, gross weight, valued at $4,801,413. These exports were shipped primarily to West Germany (21%), Canada (17%), Japan (16%), Belgium-Luxembourg (10%), Brazil (9%), the United Kingdom (8%), and Mexico (7%). Wrought tungsten and tungsten alloy exports rose 75% during the year to 155,073 pounds, gross weight, valued at

$2,153,683. Most of these exports were shipped to Japan (37%), Canada (23%), West Germany (13%), and the United Kingdom (9%).

Imports.—Imports for consumption of tungsten concentrate increased 84% during the year and totaled almost 10.6 million pounds of contained tungsten, the highest import level since 1957. The major sources of concentrate imports in 1973 were Canada (30%), Bolivia (21%), Peru (10%), and Thailand (9%).

During the year, imports of tungsten carbide, primarily from West Germany (84%) and Sweden (14%), decreased 19% and totaled 208,561 pounds of contained tungsten valued at $1,497,415. Imports of waste and scrap containing over 50% tungsten decreased 25% and totaled 78,711 pounds of tungsten content valued at $255,199. This material was received primarily from West Germany (44%), the Netherlands (26%), and Japan (14%). Imports of unwrought tungsten (except alloys)

Table 8.—U.S. exports of tungsten ore and concentrate, by country

(Thousand pounds and thousand dollars)

Country	1972			1973		
	Gross weight	Tungsten content [1]	Value	Gross weight	Tungsten content [1]	Value
Ireland	(2)	(2)	(2)	--	--	--
Netherlands	116	60	161	146	75	204
United Kingdom	67	35	50	28	15	35
Total	183	95	211	174	90	239

[1] Tungsten content estimated by multiplying the gross weight by a factor of 0.516.
[2] Less than ½ unit.

Table 9.—U.S. exports of ammonium paratungstate, by country

(Pounds)

Country	1972			1973		
	Gross weight	Estimated tungsten content [1]	Value	Gross weight	Estimated tungsten content [1]	Value
Canada	--	--	--	21,000	14,839	$60,480
Colombia	1,017	719	$2,033	--	--	--
Ecuador	750	530	2,668	--	--	--
Ethiopia	--	--	--	388	274	775
France	437	309	874	--	--	--
Germany, West	89,600	63,311	170,039	88,026	62,199	174,183
Guatemala	863	610	1,230	--	--	--
Ireland	657	464	1,314	--	--	--
Japan	1,042	736	2,084	304,981	215,500	539,034
Mexico	250	177	500	--	--	--
Peru	--	--	--	890	629	1,780
Philippines	--	--	--	84	59	518
South Africa, Republic of	--	--	--	400	283	628
Syria	864	611	1,728	--	--	--
Total	95,480	67,467	182,470	415,769	293,783	777,398

[1] Estimated contained weight obtained by multiplying the gross weight by 0.7066.

Table 10.—U.S. exports of ferrotungsten, by country

(Pounds)

Country	1972			1973		
	Gross weight	Estimated tungsten content [1]	Value	Gross weight	Estimated tungsten content [1]	Value
Canada	20,270	16,216	$81,066	9,574	7,659	$38,298
Mexico	--	--	--	3,200	2,560	12,175
Venezuela	986	789	3,700	--	--	--
Total	21,256	17,005	84,766	12,744	10,219	50,473

[1] Estimated tungsten content obtained by multiplying the gross weight by 0.80.

Table 11.—U.S. exports of tungsten alloy powder

(Pounds)

Country	1972 Gross weight	1972 Estimated tungsten content [1]	1972 Value	1973 Gross weight	1973 Estimated tungsten content [1]	1973 Value
Argentina	100	78	$669	--	--	--
Australia	30,148	23,515	68,364	5,078	3,961	$25,321
Austria	13,968	10,895	67,301	18,591	14,501	83,025
Belgium-Luxembourg	4,336	3,382	35,967	36,316	28,326	164,025
Brazil	2,407	1,877	23,447	9,042	7,053	43,657
Canada	237,941	185,594	609,285	128,495	100,226	713,162
Chile	7,792	6,078	1,350	--	--	--
Costa Rica	9,936	7,750	4,126	--	--	--
Denmark	450	351	1,848	--	--	--
Finland	50	39	746	7,711	6,015	36,161
France	27,665	21,579	64,548	430	335	3,955
Germany, West	62,996	49,137	503,419	58,503	45,632	312,960
India	--	--	--	895	698	4,247
Ireland	22	17	982	1,175	917	10,175
Israel	21,459	16,738	101,875	30,259	23,602	142,333
Italy	29,745	23,201	248,876	2,304	1,797	10,895
Japan	22,656	17,672	62,215	137,779	107,468	646,315
Libya	100	78	608	--	--	--
Mexico	129,770	101,221	244,628	11,855	9,247	61,502
Netherlands	25,601	19,969	151,027	--	--	--
Portugal	60	47	654	--	--	--
South Africa, Republic of	1,718	1,340	14,479	--	--	--
Spain	--	--	--	208	162	2,550
Sweden	13,529	10,553	20,966	4,537	3,539	23,082
Switzerland	11,619	9,063	76,869	2,121	1,654	19,029
Taiwan	--	--	--	300	234	3,600
Turkey	90	70	1,373	--	--	--
United Kingdom	8,084	6,305	36,136	2,034	1,587	10,941
Venezuela	800	624	3,680	--	--	--
Total	663,042	517,173	2,345,438	457,633	356,954	2,316,935

[1] Estimated tungsten content obtained by multiplying the gross weight by 0.78.

in lump, grain, and powder fell 61% to 55,601 pounds of contained tungsten valued at $298,561 and were received primarily from West Germany (47%), the United Kingdom (37%), Sweden (12%), and East Germany (3%).

In 1973, imports of unwrought tungsten, n.e.c., totaled 45,509 pounds, gross weight, valued at $160,101, and were received from West Germany (73%), and France (27%). Wrought tungsten imports tripled during the year and totaled 16,620 pounds, gross weight, valued at $762,156. This material was imported primarily from Japan (31%), Switzerland (23%), Austria (13%), Brazil (12%), the Netherlands (11%), and Sweden (7%).

Imports of tungsten material classified as "metal-bearing materials in chief value of tungsten" increased by a factor of almost three during 1973 and totaled 266,842 pounds of contained tungsten valued at $574,156. These imports were received primarily from Thailand (56%) and the Republic of Korea (42%). Most of the material imported under this classification was believed to be synthetic scheelite. In addition, 219,567 pounds of contained tungsten was imported, all from the Republic of Korea, as ammonium tungstate valued at $608,042. This material was upgraded at the new South Korean tungsten processing facility.

Calcium tungstate imports, almost all from West Germany, increased 35% in 1973 and totaled 36,814 pounds of contained tungsten, value at $389,527.

During the year the tariff rates on all forms of tungsten imports from non-Communist and Communist countries remained unchanged.

Table 12.—U.S. imports[1] of tungsten ore and concentrate, by country

(Thousand pounds and thousand dollars)

Country	1972			1973		
	Gross weight	Tungsten content	Value	Gross weight	Tungsten content	Value
Argentina	--	--	--	111	59	61
Australia	695	392	951	551	320	748
Bolivia	1,568	880	1,624	3,910	2,183	4,659
Brazil	223	123	251	760	433	932
Burma	--	--	--	56	31	54
Canada	2,721	1,634	3,507	5,303	3,189	7,555
Chile	--	--	--	132	74	131
China, People's Republic of	--	--	--	154	81	214
France	--	--	--	168	56	111
Germany, West	975	257	588	711	267	332
Guatemala	--	--	--	2,232	371	46
Kenya	91	54	234	--	--	--
Korea, Republic of	641	370	734	964	547	1,145
Malaysia	288	166	354	568	323	685
Mexico	198	107	218	614	333	727
Peru	1,162	670	1,162	1,742	1,039	2,064
Portugal	14	9	24	303	176	470
Rwanda	121	72	133	202	108	238
South Africa, Republic of	--	--	--	151	82	199
Spain	--	--	--	100	56	138
Thailand	1,903	1,069	2,323	1,569	843	1,815
Uganda	--	--	--	22	11	32
Zaire	175	95	213	338	183	417
Total	10,775	5,898	12,316	20,661	10,765	22,773

[1] Data are "general imports;" that is, they include tungsten imported for immediate consumption plus material entering warehouses.

Table 13.—U.S. imports for consumption of tungsten ore and concentrate, by country

(Thousand pounds and thousand dollars)

Country	1972			1973		
	Gross weight	Tungsten content	Value	Gross weight	Tungsten content	Value
Argentina	--	--	--	111	59	61
Australia	695	392	951	551	320	748
Bolivia	1,390	780	1,443	3,912	2,183	4,659
Brazil	223	124	265	815	465	989
Burma	--	--	--	56	31	55
Canada	2,721	1,634	3,507	5,303	3,189	7,555
Chile	--	--	--	132	74	131
China, People's Republic of	--	--	--	154	81	214
France	--	--	--	168	56	111
Germany, West	975	257	588	711	267	332
Kenya	91	54	234	--	--	--
Korea, Republic of	641	370	734	964	547	1,145
Malaysia	288	166	354	568	323	685
Mexico	165	90	200	646	348	745
Peru	1,407	814	1,516	1,742	1,039	2,064
Portugal	14	9	24	303	176	470
Rwanda	176	100	191	202	108	238
South Africa, Republic of	--	--	--	151	82	199
Spain	--	--	--	100	56	138
Thailand	1,581	883	1,976	1,776	954	2,050
Uganda	--	--	--	22	11	32
Zaire	120	66	156	338	183	416
Total	10,487	5,739	12,139	18,725	10,552	23,037

Table 14.—U.S. imports for consumption of ferrotungsten, by country

(Pounds)

Country	1972			1973		
	Gross weight	Tungsten content	Value	Gross weight	Tungsten content	Value
Austria	30,864	24,691	$64,400	405,982	333,166	$979,121
Belgium-Luxembourg	--	--	--	11,023	9,310	25,352
Canada	238,595	189,643	501,288	53,845	41,848	115,594
France	12,787	10,024	27,171	33,069	25,906	73,087
Germany, West	114,580	88,171	228,077	197,891	157,367	406,522
Norway	9,000	6,975	19,844	--	--	--
Portugal	126,103	104,737	275,284	94,357	78,894	209,978
Sweden	55,115	44,935	110,019	--	--	--
United Kingdom	427,980	344,746	943,143	596,131	460,016	1,295,154
Total	1,015,024	813,922	2,169,226	1,392,298	1,106,507	3,104,808

Table 15.—U.S. imports for consumption of tungsten and tungsten carbide forms

(Thousand pounds and thousand dollars)

Year	Ingots, shot, bars, scrap		Wire, sheets, other forms, n.s.p.f.		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1971 r	227	822	236	1,602	463	2,424
1972 r	467	1,232	624	2,309	1,091	3,541
1973	730	1,431	703	3,516	1,433	4,947

r Revised.

Table 16.—Tungsten: Estimated world reserves and resources, by major country

(Million pounds of contained tungsten)

Country	Reserves	Resources
North America:		
Canada	24	28
United States	175	300
South America:		
Bolivia	87	105
Brazil	40	60
Europe:		
Portugal	22	30
U.S.S.R. e	27	35
Asia:		
Burma	67	90
China, People's Republic of e	2,000	2,000
Malaysia	32	40
North Korea e	105	115
Republic of Korea (South)	101	110
Thailand	10	20
Oceania: Australia	25	30
Other	45	97
Total	2,760	3,060

e Estimate.

WORLD RESERVES AND RESOURCES

At yearend 1973, domestic reserves and resources of tungsten as reported by the U.S. Geological Survey and the Bureau of Mines totaled about 175 million pounds and 300 million pounds of tungsten, respectively.[5]

Estimated world reserves and resources of tungsten at yearend, totaled 2,750 million pounds and 3,060 million pounds of contained tungsten, respectively, as indicated in table 17.[6]

[5] Hobbs, S. W., and J. E. Elliott. Tungsten. Ch. in United States Mineral Resources. U.S. Geol. Survey Prof. Paper 820, 1973, pp. 667–678. Work cited in footnote 5.

[6] Business Week. The Scramble for Resources. No. 2286, June 30, 1973, pp. 56–63. Miller, J. R. Metals Resources—Tungsten. J. Metals, v. 25, No. 9, September 1973, pp. 222–224.

Table 17.—Tungsten: World production by country

(Thousand pounds of contained tungsten [1])

Country [2]	1971	1972	1973 p
North America:			
Canada [3]	3,667	3,527	4,594
Guatemala	e 90	18	348
Mexico	899	798	767
United States	6,900	8,150	7,575
South America:			
Argentina	r 304	154	e 155
Bolivia [4]	4,608	4,923	4,815
Brazil [5]	r 2,989	2,515	2,097
Peru	r 1,673	1,887	1,753
Europe:			
Austria	99	--	--
France	r 163	1,237	1,532
Portugal	2,176	3,093	3,333
Spain	897	798	789
Sweden e	--	90	570
U.S.S.R. e	15,400	15,900	16,300
United Kingdom	11	4	e 4
Africa:			
Niger	e 2	--	--
Nigeria	e 2	e 2	3
Rhodesia, Southern [6]	409	333	339
Rwanda e	440	570	570
South Africa, Republic of	15	1	1
South-West Africa, Territory of [7]	209	196	49
Tanzania	r 12	6	2
Uganda	243	240	e 240
Zaire	r 708	635	531
Asia:			
Burma	842	992	1,102
China, People's Republic of e	15,400	r 16,500	17,600
India	33	37	24
Japan	r 1,609	1,978	2,072
Korea, North e	4,740	4,740	4,750
Korea, Republic of	r 4,784	4,374	4,965
Malaysia	20	12	e 15
Thailand	5,527	7,370	5,736
Oceania:			
Australia	r 3,175	3,373	2,687
New Zealand	r 9	17	2
Total	r 78,055	84,470	85,320

e Estimate. p Preliminary. r Revised.

[1] Conversion factors: WO_3 to W multiply by 0.7931; 60% WO_3 to W multiply by 0.4758.

[2] In addition to the countries listed, Czechoslovakia reported tungsten production from tin-tungsten ores in previous years. It is not known if the production had continued to the present.

[3] Producer's shipments; actual production data is not officially reported, but available company figures indicate a substantial difference between actual output and shipments in some years.

[4] Data are the sum of production reported by COMIBOL and export credited to medium and small mines.

[5] Figures exceed those reported in official Brazilian sources; these sources do not include production by small mines, which in aggregate appear to be substantial.

[6] Production from Beardmore mine only, and are for the year ended September 30 of the year stated.

[7] Data are for South West Africa Co. Ltd. only, and are for the year ended June 30 of the year stated.

WORLD REVIEW

The Committee on Tungsten of the United Nations Conference on Trade and Development (UNCTAD) met in Geneva, Switzerland, late in the fall to discuss methods of stabilizing world prices, obtaining more detailed ore reserve data and evaluating statistical data on tungsten concentrate trade and product consumption. Membership in the Working Group, a subsidiary of the Committee on Tungsten, was further expanded to include Japan, the Netherlands, Thailand, the United Kingdom, and the U.S.S.R. Other members of the Working Group are Australia, Austria, Bolivia, Portugal, the Republic of Korea, Sweden, the United States, and West Germany. The Committee staff continued to canvass, tabulate, and report detailed statistics on tungsten production, consumption, and trade in the quarterly bulletin, "Tungsten Statistics."[7] Copies of these reports are $3 each and are available on a standing order basis from the United Nations Sales Section, Geneva, Switzerland, or New York.

A comprehensive evaluation of the present status of tungsten powder metallurgy in Canada, Italy, Japan, Romania, Spain, Sweden, the United Kingdom, the United States, the U.S.S.R., and West Germany was released during the year.[8]

Australia.—Aberfoyle Ltd. ceased tungsten production from the company's Storeys Creek facilities in Tasmania at mid-year 1973 and the operations were placed on

[7] UNCTAD Committee on Tungsten (Geneva, Switzerland). Tungsten Statistics. V. 7, Nos. 1–4, 1973.

[8] American Powder Metallurgy Institute. (Princeton, N.J.). Internat. J. Powder Metallurgy, v. 9, No. 3, July 1973, 100 pp. (entire issue).

Table 18.—Tungsten: World concentrate consumption, by country

(Thousand pounds of contained tungsten)

Country [1]	1971	1972	1973 [p]
Actual consumption:			
Australia	88	88	[e] 88
Austria	3,417	3,109	2,690
Czechoslovakia	[e] 2,900	[e] 3,000	[e] 3,031
France	2,467	2,734	3,854
Japan	4,579	5,128	7,740
Portugal	498	679	728
Sweden	3,228	3,040	2,806
United Kingdom	4,819	7,205	7,900
United States	11,622	14,107	15,386
Apparent consumption, excluding stock variations: [2]			
Argentina	84	97	115
Belgium-Luxembourg	[e] 66	108	145
Brazil	463	[e] 494	[e] 525
Bulgaria [e 3]	75	70	65
Canada	[e] 441	[e] 551	[e] 560
China, People's Republic of [e 3]	4,000	4,500	4,500
Germany:			
East [e 3]	750	700	700
West	5,324	5,514	7,280
Hungary [e 3]	50	50	50
India	412	423	430
Italy	126	104	110
Korea:			
North [e 3]	3,500	3,500	3,500
South [4]	--	--	[e] 550
Netherlands	613	1,581	1,650
Poland	3,876	3,993	4,081
Romania [e 3]	30	30	30
South Africa, Republic of	[e] 582	794	850
Spain	203	284	340
U.S.S.R. [e 3]	14,200	14,700	14,800
Total	[r] 68,413	[r] 76,583	84,504

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition, the following countries may consume tungsten concentrate but specific data are not available: Denmark, Finland, Israel, Norway, Switzerland, and Yugoslavia.

[2] Production plus imports minus exports.

[3] Estimated by author of chapter.

[4] Data represents tungsten concentrate consumed to make ammonium paratungstate at new APT plant adjacent to Sangdong mine.

Primary source: UNCTAD Committee on Tungsten quarterly reports "Tungsten Statistics" and Annual Company Reports.

"standby" status.[9] Tungsten production from the adjacent tin-tungsten Aberfoyle mine was continued at a rate of 180 to 200 tons per day.

King Island Scheelite, Ltd., a subsidiary of Peko-Wallsend Ltd., continued to develop the Bold Head tungsten ore body in Tasmania.[10] Some development ore was available by late 1973, and full production is expected by mid-1975. When full-scale production is achieved, the Bold Head project is expected to have a capacity of about 200,000 tons per year of tungsten ore. King Island Scheelite has also announced plans to construct a plant to recover the molybdenum contained in the scheelite ores.

Canada.—During 1973, Canada Tungsten Mining Corp. Ltd. (CTMC), the country's major tungsten producer, at Tungsten, Northwest Territories, completed open pit mining operations and stockpiled a total of 103,670 tons of ore averaging 1.60% WO_3.[11]

At yearend, ore reserves amounted to 177,600 tons of scarn-type ore grading 1.62% WO_3 and 73,600 tons averaging 0.71% WO_3. This material could only be mined by using underground methods.

A total of 164,900 tons of ore containing an average of 1.22% WO_3 and 0.161% of copper (Cu) were processed during the year. Total production amounted to 161,430 stu WO_3 (almost 2.6 million pounds of contained tungsten). Overall mill recovery of WO_3 averaged 80.2% for the year. The concentrator operated a total of 90.1% of possible time and treated an average of 452 tons per day. Milling of the lower grade chert ore was discontinued in August when the higher grade skarn-type ore from the open pit became available. This resulted in a more efficient milling operation.

In addition to the scheelite concentrate, 197,861 pounds of byproduct copper concentrate was produced during 1973, a decrease of 12% compared with 1972 production.

At yearend CTMC estimated its chert ore reserves in place to total about 615,000 tons averaging 0.81% WO_3 (about 10 million pounds of contained tungsten). Stockpile balances at December 31, 1973, amounted to 34,460 tons of scarn ore grading 1.73% WO_3 for 59,507 short ton units (0.9 million pounds of contained tungsten) and 63,907 tons of chert ore grading 1.17% WO_3 for 74,528 short ton units (almost 1.2 million pounds of contained tungsten).

CTMC announced plans to commence underground mine production on a steady basis at Tungsten during 1974. The proven underground ore reserves totaled 4,242,000 tons at an average grade of 1.68% WO_3 for 7,106,000 short ton units (almost 113 million pounds of contained tungsten). This material should be sufficient for a 20-year supply at a milling rate of 500 to 600 tons per day.

The Vancouver Leach Plant of CTMC in North Vancouver, British Columbia, operated well during the year with overall recovery of 96.99%. There were no significant changes in the leach plant operation.

Mining at the Canex Tungsten Division of Placer Development Ltd. near Salmo, British Columbia, was completed in September 1973, and mill operations ceased.[12]

Underground production decreased as the ore reserves were depleted. Subsequently, the equipment and most of the buildings were sold at public auction. A termination allowance was provided by the company to assist employees put out of work by the closure.

AMAX Exploration Inc., a subsidiary of American Metal Climax Inc., identified a significant scheelite deposit of over 30 million tons of ore averaging 0.9% WO_3 in the MacMillan Pass district on the Yukon-Territories border northwest of Whitehorse. Further drilling and evaluation is required to fully outline the deposit.

China, People's Republic of.—The richest and most extensive tungsten deposits in the world are located in the south of China, along the Nan Ling Range. They extend from the southwest to the northeast, roughly parallel to the southwestern coast.[13]

A Japanese trade association indicated interest in obtaining Chinese tungsten concentrate if the material, which was re-

[9] Aberfoyle Ltd. (Melbourne, Australia). 1972–73 Annual Report. 13 pp.
[10] Peko-Walland (Sydney, Australia). 1972–73 Annual Report. 32 pp.
[11] Canada Tungsten Mining Corp. Ltd. (Toronto, Canada). 1973 Annual Report. 9 pp.
[12] Placer Development Ltd. (Vancouver, Canada). 1973 Annual Report. 32 pp.
[13] Canadian Mining Journal. CMJ and the Canadian Minerals and Metals Mission to China. V. 94, No. 1, January 1973, pp. 19–31.
Mamen, C. China Report—Part Two: Mines and Plants Visited. Can. Min. J., v. 94, No. 3, March 1973, pp. 28–34.
U.S. Embassy, Ottawa, Canada. Minerals and Metallurgy: Canadian Mission to PRC, November-December 1972. State Department Airgram A-238, May 12, 1973, 36 pp.

portedly far below Japanese standards, were upgraded. It is believed that the Chinese made subsequent efforts to upgrade the quality of their concentrate.

A sample analysis of Chinese tungsten concentrate being sold for export indicated the material to be mostly wolframite, with very little scheelite, containing about 65.6% WO_3. In addition, spectrographic analysis showed that the material contained 10% or more of iron, and 1% to 10% of aluminum, manganese, and silicon. Because of the lack of knowledge regarding the methods of processing concentrate, it is recognized that this material does not necessarily represent a true sampling of Chinese tungsten concentrate, but the analysis gives an indication of the type and grade of material available from China.

To promote trade with the People's Republic of China, several reports were prepared.[14] To keep abreast of the current activity in the People's Republic of China, a subscription to Translations From the Mainland China Press is available from the National Technical Information Service (NTIS) in Springfield, Va.

Reportedly, the status of powder metallurgy technology in the People's Republic of China is rapidly expanding, and the sintered carbide tools, which China exports to foreign countries, are suppose to be of high quality.[15]

Guatemala.—A medium sized coproduct mining operation, F. Y. Wellman Co., recovered tungsten and antimony (Sb) semiconcentrates, primarily for export, in the Department of Huehuetenango. Combined mine production (Sb plus WO_3) was about 165 short tons per month. In 1973 antimony production rose 63% while production of coproduct tungsten increased by a factor of almost 20. Most of this combined concentrate was shipped by rail through Mexico to the smelter of NL Industries, Inc., at Laredo, Tex., for further processing. At Laredo, a tungsten recovery circuit is scheduled to begin processing the imported tungsten semi-concentrate containing about 22% WO_3 in mid-1974 to a commercial grade concentrate (65% to 70% WO_3).

Japan.—The demand for tungsten in 1973 was extremely strong as Japanese consumption increased about 50% to 7.7 million pounds of tungsten. The Japanese tungsten utilization ratio was about as indicated in the following:

Industry	*Percent*	*Form*
Iron and Steel	40	Ferrotungsten.
Electronics (tungsten mill products).	30	Tungsten metal powder.
Tungsten carbide cutting tools.	29	Tungsten carbide.
Chemical	1	Ammonium paratungstate.

Because only about 1.9 million pounds of tungsten was recovered domestically, the remainder of demand comprised imports. In early December, the Japanese Tungsten and Molybdenum Association sent a mission to the People's Republic of China to negotiate purchase of 0.9 million pounds of tungsten for 1974 and to establish a long-term agreement that would give Japan an assured source of supply. In the near future, Japan reportedly plans to recover tungsten from tailings material.

The Uji ferroalloy works of the Awamura Metal Industry Co., in Osaka was the country's only ferrotungsten producer.[16] An electric furnace process is used. The three domestic producers of tungsten metal powder were Japan New Metals, Nakahara Construction, and Japan Heavy Metals. Their combined output was 2,020 tons, up nearly 40% from 1972.

Korea, Republic of.—The Korea Tungsten Mining Co. Ltd., (KTMC), which is owned 15.5% by the Government, continued to be the country's major tungsten producer during 1973 and accounted for 92.1% of the domestic supply.[17] As shown in the following tabulation, KTMC's Sangdong mine accounted for 90.6% of Korean production:

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[14] Driscoll, G. Overseas Business Reports: Basic Data on the Economy of the People's Republic of China. Bureau of International Commerce, OBR 72-047, September 1972, 39 pp.; available from the U.S. Department of Commerce field offices or from the U.S. Government Printing Office.

Phipps, J., and J. Matheson. Overseas Business Reports: Trading With the People's Republic of China. Domestic and International Business Administration, OBR 73-16, May 1973, 25 pp.; available from the U.S. Department of Commerce, field offices or from the U.S. Government Printing Office.

U.S. Library of Congress. People's Republic of China: International Trade Handbook. Research Aid A 72-38, December 1972, 33 pp.

[15] Page 219 of work cited in footnote 8.

[16] Metal Bulletin Monthly (London). Ferro-Alloys Review. No. 40, April 1974, 63 pp.

[17] U.S. Embassy, Seoul, Korea. Tungsten Stocks. State Department Airgram A-110, May 2, 1974, 1 p.

Company	Short tons (gross weight)
Bando Mining Co. Ltd	23
Kaya Ind. Co., Ltd	84
Korea Tungsten Mining Co., Ltd.:	
Dalsong mine	65
Sangdong mine	3,909
Okbang Mining Co., Ltd	203
Wolak Mining Co., Ltd	NA
Other companies[1]	32
Total	4,316

NA Not available.
[1] About 6 mines.

Stocks of tungsten, primarily tungsten concentrate and chemicals, at yearend, fell 79% compared with those of 1972.

Mongolia.—The capacity of the tungsten mine and ore processing plant in Burentsogt, about 100 miles southeast of Ulan Bator, was doubled as a result of expansion and reconstruction conducted with technical and economic assistance from East German specialists. It appears possible that some of the Mongolian tungsten production, previously sent to the U.S.S.R. for further processing, will be exported to East Germany as repayment for technical assistance.

Portugal.—Beralt Tin and Wolfram Ltd. transferred all its holding in the Panasqueira, Barroca Grande, and Rio operations to Beralt Tin & Wolfram (Portugal) SARL, a Portuguese incorporated company, for an 80.55% equity interest in the new company.[18] Portuguese banking interests subscribed the equivalent of £1 million (about $2.5 million) for the remaining 19.45% interest. Production of tungsten at the Panasqueira mine increased as higher ore grade was recovered as a result of the recent development program carried out in the southern areas. The development program has been selective, and the resulting improvement in ore reserves will enable a satisfactory grade of tungsten to be mined during the next few years.

The tungsten-tin-copper ore concentration plant at Barroca Grande and the mill at Rio operated satisfactorily throughout the year with slightly improved recoveries.

The local labor supply continued to be unsatisfactory, and high periodic absenteeism created difficulties. Recruitment from the Cape Verde Island continued and the recruitment campaign for local employees was intensified.

Rhodesia, Southern.—During 1973, Rhodesian tungsten continued to be recovered from the Beardmore mine and mill, operated by the Messina (Transvaal) Development Co., Ltd., near Bikita.[19] An evaluation of Beardmore's stocks indicated that enough material was available to allow underground mining to continue through December. When this material has been mined the company plans to reprocess selected portions of the slime and sand dumps to produce about 100 tons of WO_3 (about 0.2 million pounds of tungsten) contained in concentrate by the end of the current financial year (June 30, 1974) when production is expected to cease.

In close association with the Tribal Trust Land Development Corp. plans for construction of an ion-exchange tungsten refinery to process tungsten from scheelite ore at a 95% recovery factor were reported.[20] The refinery, using considerable scheelite from tribal areas, is expected to be built at Ntabazinduna or in the Bulawayo industrial area about 200 miles southwest of Salisbury.

Sweden.—Tungsten concentrate was recovered by AB Statsgruvor at its Yxsjöberg mill in central Sweden. Full scale production has been under way since the beginning of November 1972 when scheelite-fluorspar ores were processed at an annual rate of 165,000 short tons of tungsten ore having an average grade of 0.3% WO_3.[21] During 1973 the mill's annual yield was reported to be about 440 tons of first-grade scheelite concentrate containing 73% WO_3 and about 110 tons of second-grade scheelite semiconcentrate containing 40% WO_3.

Thailand.—The recovery of tungsten concentrate from large deposits recently discovered at Khao Soon and Doi Mok in the southern peninsula area resulted in the substantial increase in tungsten production during the early 1970's. Mining methods used at these operations by thousands of peasants were extremely dangerous. Following the heavy rains in 1973, landslides caused the Doi Mok mine disaster, which involved several fatalities and closure of the mine. During 1973, Thai tungsten

[18] Beralt Tin and Wolfram Ltd. (London). 1973 Annual Report. 20 pp.
Charter Consolidated Ltd. (London). 1973 Annual Report. 50 pp.

[19] Messina (Transvaal) Development Co., Ltd. (Johannesburg, Republic of South Africa). 1973 Annual Report. 28 pp.

[20] Chamber of Mines Journal (Salisbury, Southern Rhodesia). $250,000 Scheelite Refinery Scheme Arouses Wide Interest: New Ion Exchange Process Will be Used. V. 15, No. 2, February 1973, p. 26.

[21] World Mining (International Edition). V. 26, No. 7, June 25, 1973, pp. 184–185.

production decreased 22% to 5.7 millon pounds of contained tungsten, 83% came from wolframite and 17% came from scheelite ores.

TECHNOLOGY

During the year, studies were continued by Bureau of Mines research scientists at the Salt Lake City Metallurgy Research Center to develop economic methods for recovering tungsten from the low-grade brine deposits of Searles Lake, Calif., which contain an estimated 135 million pounds tungsten. If recoverable, this could almost double the Nation's tungsten reserves. Bureau of Mines research engineers at Salt Lake City also evaluated methods for economically recovering tungsten and associated metals from oxide ores, machining wastes, and alloy scrap. Under this program, about 90% of the electrochemical machining sludges were recycled from the brine electrolyte.

Research metallurgical engineers at the Bureau of Mines Albany (Oregon) Metallurgy Research Center conducted two extensive evaluations of tungsten carbide coal cutters as part of studies on nonsparking steels and on ignition hazards due to frictional sparks.

A comprehensive bibliography of tungsten technology, published quarterly, is available from Climax Molybdenum Co., Greenwich, Conn.[22]

Studies conducted by Bureau of Mines metallurgists at the Boulder City (Nevada) Metallurgy Research Laboratory evaluated mixtures of sized tungsten carbide (WC) particles and solvent degreased Titanium—6% Aluminum—4% Vanadium alloys, which were compacted in a hydraulic press.[23]

A second annual report highlighting Bureau of Mines minerals research and reviewing molybdenum-tungsten research programs was published during the year.[24]

Studies of chemical vapor deposition (CVD) methods used in tungsten processing techniques were evaluated to determine the optimum conditions of temperature and pressure for hydrogen reduction of tungsten hexfluoride (WF_6).[25]

Although cladding tungsten with a palladium-gold gave only short-term protection against oxidation, the addition of tungsten to a Pd-33% Au alloy resulted in a stable coating for tungsten.[26]

A Soviet research study indicated that titanium coatings could be satisfactorily diffusion bonded to tungsten.[27]

Diffusion bonding and metallic spray coating by explosive bonding, results in a smooth tungsten coating with little oxide.[28] The adhesion strength of tungsten coatings prepared in this method is greater than that obtained by other, more conventional, spraying methods.

Tungsten-urania nuclear fuel elements developed for elevated temperature use in nuclear reactors were clad with coarse-grained tungsten to avoid loss of UO_2.[29]

Detailed studies of the electrochemical deposition of sodium tungsten bronzes were conducted during the year.[30]

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[22] Climax Molybdenum Co. Tungsten News. January, April, July, and October 1973, and January 1974, 20 pp. each.

[23] Leone, O. Q., and D. E. Couch. Cleaning Titanium Alloy Chips. BuMines RI 7711, 1973, 18 pp.

[24] U.S. Bureau of Mines. Bureau of Mines Research 1972: A Summary of Significant Results in Mining, Metallurgy and Energy. 1973, 82 pp.

[25] Bryant, W. A., and G. H. Meier. Kinetics of the Chemical Vapor Deposition of Tungsten. J. Electrochem. Soc., v. 120, No. 4, April 1973, pp. 559–565.

[26] Materials Engineering. Refractory Metals Fight Heat, Resist Corrosion. V. 77, No. 6, June 1973, pp. 38–41.

[27] Shapovalov, V. P., and A. N. Kurasov. Titanium Diffusion Coatings on Refractory Metals. Izvestiya AN SSSR Met., (Moscow, U.S.S.R.), March-April 1973, pp. 234–237.

[28] Fukunaga, H., H. Ito, S. Fukuda, and T. Suhara. Metallic Spray Coating by Explosion. Nippon Tungsten Rev. (Tokyo, Japan), No. 6, 1973, pp. 87–95.

[29] McDonald, G. E. (assigned to the National Aeronautics and Space Administration). Nuclear Fuel Elements. U.S. Pat. 3,759,787, Sept. 18, 1973.

[30] Bockris, J. O'M., and J. McHardy. Electrocatalysis of Oxygen Reduction by Sodium Tungsten Bronze: II. The Influence of Traces of Platinum. J. Electrochem. Soc., v. 120, No. 1, January 1973, pp. 61–66.

McHardy, J., and J. O'M. Brockris. Electrocatalysis of Oxygen Reduction by Sodium Tungsten Bronze: I. Surface Characteristics of a Bronze Electrode. J. Electrochem. Soc., v. 120, No. 1, January 1973, pp. 53–60.

Randin, J. P., Electrochemical Deposition of Sodium Tungsten Bronzes. J. Electrochem. Soc., v. 120, No. 10, October 1973, pp. 1325–1330.

———. Kinetics of Anodic Oxide Growth on Sodium Tungsten Bronzes. J. Electrochem. Soc., v. 120, No. 3. March 1973, pp. 378–381.

Randin, J. P., A. K. Vijh, and A. B. Chughta. Electrochemical Behavior of Sodium Tungsten Bronze Electrodes in Acidic Media. J. Electrochem. Soc., v. 120, No. 9, September 1973, pp. 1174–1184.

Uranium

By Walter C. Woodmansee [1]

Following several years of slack demand and soft prices for uranium, the uranium and nuclear industries started an upward trend in 1973. This improved market was expected to gather momentum in 1974. The year 1973 was a good one in terms of new operable commercial power reactors and orders placed for reactor construction licenses. The Atomic Energy Commission (AEC) made progress in expediting the licensing procedure and planned to reduce the lead time required between the start of commercial nuclear reactor construction and operation from 8 to 9 years to 5 to 6 years.

Mine output was slightly reduced from that of 1972 in terms of U_3O_8 content of ore, but mill output continued an upward trend started in 1971. A number of small mines, mainly in Colorado, and two mills in Texas were closed during the year, but major, new mine-mill complexes were under construction in Wyoming and New Mexico.

Exploration for uranium continued strong, and a small net addition was made to domestic ore reserves, although the discovery rate (per foot drilled) was unfavorable. The Grand Junction, Colo., office of the AEC invited bids for mining leases on AEC-controlled lands, which contain substantial ore reserves. The Grand Junction office also announced the start of a multiyear national survey to evaluate low-grade potential uranium resources.

[1] Physical scientist, Division of Nonferrous Metals—Mineral Supply.

Table 1.—Salient uranium concentrate (U_3O_8) statistics

(Short tons U_3O_8 unless otherwise specified)

	1969	1970	1971	1972	1973
Production:					
Domestic:					
Mine: [1]					
Ore ____thousand tons__	5,904	6,324	6,279	6,418	6,537
Content of ore ____	12,281	12,768	12,907	13,667	13,588
Average grade of ore _percent U_3O_8__	0.208	0.202	0.205	0.213	0.208
Recoverable [e] [2] ____	11,870	12,190	12,260	12,880	12,900
Value [e] [3] ____thousands__	$142,161	$147,569	$151,996	$162,272	$167,700
Mill, concentrate [4] ____	11,609	12,905	12,273	12,900	13,235
World [e] [5] ____	23,083	24,161	[r] 23,909	[r] 25,625	25,486
Deliveries of concentrate:					
Atomic Energy Commission:					
Quantity ____	6,184	2,520	--	--	--
Value ____thousands__	$72,336	$28,078	--	--	--
Price per pound ____	$5.85	$5.59	--	--	--
Private industry [e] ____	6,200	9,300	12,800	11,600	12,100
Imports, concentrate ____	1,504	665	942	[r] 2,329	5,605
Reserves [6] ____thousand tons__	204	246	273	273	277
Employment [7] ____number of persons__	9,059	8,165	7,373	6,403	6,595

[e] Estimate. [r] Revised.
[1] Receipts at mills; excludes uranium from leaching operations, mine waters, and refinery residues.
[2] Based on mill recovery factors.
[3] Market value based on recoverable U_3O_8 content, average AEC price for U_3O_8, and estimated average private price for 1969–70; based on estimated average private price only in 1971–73.
[4] Includes marketable concentrate from leaching operations.
[5] Non-Communist only.
[6] At $8 per pound U_3O_8.
[7] In exploration, mining, and milling, at yearend.

Sources: U.S. Atomic Energy Commission and Federal Bureau of Mines.

Gas-centrifuge development for uranium enrichment progressed and will provide an alternative to gaseous diffusion enrichment technology. It was generally agreed that new enrichment capacity will be needed in the early 1980's, and the AEC initiated programs that offered AEC-developed enrichment technology to private industry for development of enrichment capability.

Development continued on private facilities to produce nuclear fuels, reprocess the burned fuels, and, in conjunction with the AEC, manage the radioactive waste products of this industry. Several sectors of the nuclear industry experienced shortages in supplies and equipment, engineers, and skilled labor.

In July, a basic contract was signed by the AEC, Tennessee Valley Authority (TVA), and private industry interests for the Nation's first demonstrator liquid metal fast breeder reactor (LMFBR) to be built in the TVA system, near Oak Ridge, Tenn.[2]

Exploration.—An industry survey conducted by the AEC's Grand Junction office indicated increased exploratory drilling footage and expenditures in 1973 and ambitious company plans for 1974–75.[3] A total of 84 companies reported total exploration expenditures of $49.5 million and land acquisition of 2.87 million acres for exploration. The number of exploration holes was sharply reduced from the 1972 total, but the average depth per hole was substantially higher. The average cost per foot drilled was $1.49. About one-half of this footage was drilled in Wyoming, 24% in New Mexico, 17% in Texas, and the remainder in 10 other States. Industry reported plans for drilling 29.1 million feet in 1974 ($72.5 million) and 33.7 million feet ($77.8 million) in 1975, a record rate. At yearend, companies held 6.9 million acres for uranium exploration.

The AEC's Grand Junction Office also announced plans for a National Uranium Resource Program. A preliminary overview program for potential resources, covering 62 projects in 42 areas, was started in March and was scheduled for completion in July 1975. A complete evaluation of domestic resource potential will continue until 1978.

Invitations to bid on 43 AEC-controlled tracts totaling 25,000 acres, mainly in the Uravan mineral belt of Colorado but also including acreage in Utah and New Mexico, were issued on October 1.[4] These lands contain uranium resources valued at $45 million to $50 million. At yearend, the AEC had issued 230 invitations for bids to interested parties and planned first-bid openings on April 1, 1974.

Table 2.—Surface drilling for uranium

	1972	1973
Type of drilling:[1]		
Exploration --thousand feet--	11,815	10,831
Development ----------do----	3,609	5,590
Total ---------------do----	15,424	16,421
Number of holes:		
Exploration	26,909	22,557
Development	9,706	11,704
Total	36,615	34,261
Average depth per hole:		
Exploration ------------feet--	439	480
Development ----------do----	371	478

[1] Does not include claim validation drilling or underground long-hole and diamond drilling.

Source: U.S. Atomic Energy Commission.

Shortages of drilling equipment and a tight skilled labor supply posed problems during the year. The larger, heavier drill rigs, needed for deeper drilling, were scarce because of demand for their use in coal and oil exploration.

A large new exploration project was announced for the Powder River Basin, Wyo. In a joint project, Denison Mines (U.S.), Ltd., will drill 510,000 feet on Nuclear Exploration and Development Co. (NEDCO) properties covering 64,000 acres during 1973–76. In addition, Pioneer Nuclear, Inc., will drill an 18,000-acre NEDCO property in the same area.[5]

Amax Uranium Corp., in an agreement with Weco Development Corp., will drill a 16,000-acre tract in the Ambrosia Lake area, McKinley County, N. Mex. Union Carbide Corp. will drill a 17,600-acre tract held jointly with New Mexico and Arizona Land Co., also in McKinley County. TVA concluded an agreement with United Nuclear Corp. (UNC) for a joint drilling program of UNC properties in Wyoming and New Mexico.

[2] U.S. Atomic Energy Commission. Ch. 3, Breeder Reactors. 1973 Annual Report to Congress. V. 1, Operating and Developmental Functions. Jan. 31, 1974, pp. 25–27.

[3] U.S. Atomic Energy Commission, Grand Junction Office. Uranium Exploration Expenditures in 1973 and Plans for 1974–75. GJO–103(74), April 1974, 9 pp.

[4] U.S. Atomic Energy Commission, Grand Junction Office. AEC Announces Uranium Leasing Program. News Release No. 645, Sept. 19, 1973, 4 pp.

[5] The Northern Miner (Toronto). Big Denison Drill Program for Wyoming Uranium Ground. V. 59, No. 11, May 31, 1973, p. 24.

Resources.—The AEC reported a net increase of 4,000 tons U_3O_8 in reserves at a cutoff cost of $8 per pound U_3O_8. The yearend total of 277,000 tons, in 129 million tons of ore at 0.21% U_3O_8, resulted from newly established reserves of 24,000 tons and depletions of 14,000 tons mined and a 6,000-ton loss due to re-evaluation of exploration data. New Mexico held 49% of this $8 reserve and Wyoming, 35%. The remainder was in nine States, principally Colorado and Utah.[6]

Table 3.—Domestic uranium resources in 1973 [1]

(Thousand tons U_3O_8)

	$8 [2]	$10 [3]	$15 [3]	$30 [3]
Resource	277	340	520	700
Potential	450	700	1,000	1,700

[1] At yearend.
[2] Cutoff cost; reserves at 1973 costs.
[3] Cutoff cost; higher cost resource includes that at lower cost.

Source: U.S. Atomic Energy Commission.

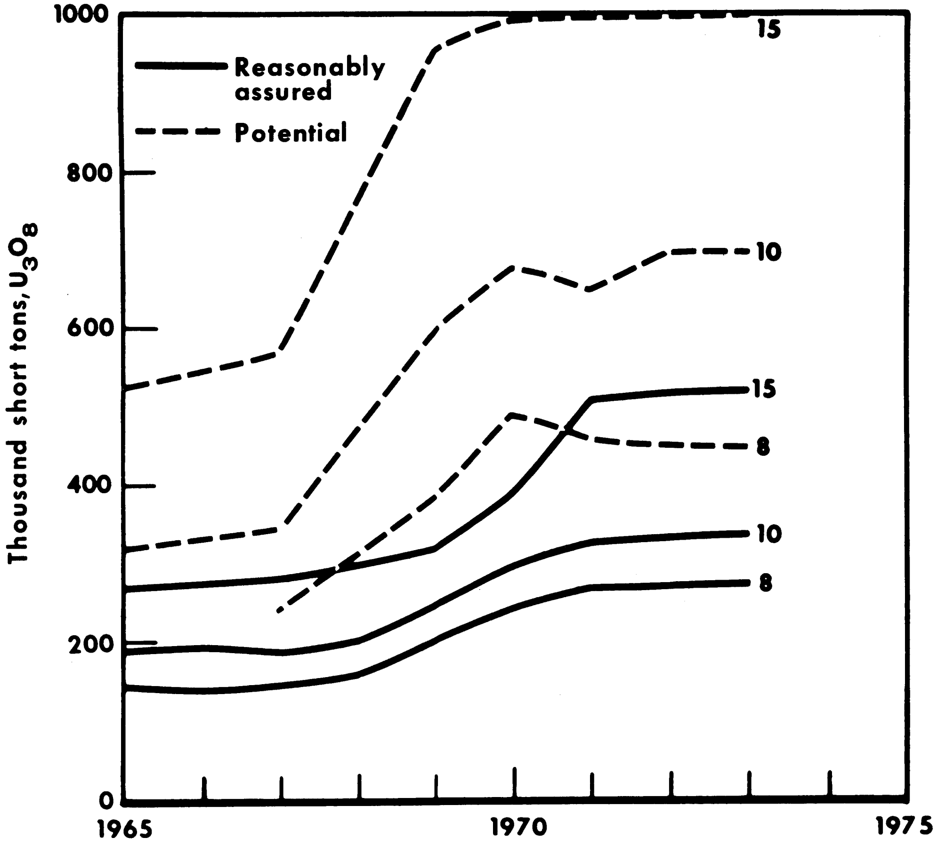

Figure 1.—Domestic uranium resources at various cutoff costs.

DOMESTIC PRODUCTION

Mine.—Mine output was higher in 1973 in terms of gross weight of ore produced but was slightly lower in terms of U_3O_8 content in ore. The number of producing mines, sharply reduced because of the closing of a number of small operations mainly in Colorado, totaled 175 properties, including 122 underground mines (4,974 tons U_3O_8), 33 open pits (8,614 tons U_3O_8),

[6] U.S. Atomic Energy Commission, Grand Junction Office. U.S. Uranium Reserves at 277,000 Tons U_3O_8. News Release No. 654, Mar. 27, 1974. 5 pp.

and 20 miscellaneous operations (199 tons U_3O_8 from mine waters, heap and in-situ leaching, and raffinate). Wyoming was the leading producing State, with nearly 39% of total U_3O_8 output; New Mexico had 36% of the output. There was no production from South Dakota in 1973.[7]

New mines were under development, particularly in New Mexico and Wyoming. Kerr-McGee Corp. was sinking a concrete shaft, 1,850 feet deep and 14 feet in diameter, near Gallup, N. Mex. Production was scheduled for 1975. The ore will go to the company's mill in the Ambrosia district. A 600-foot shaft was being sunk at the L Bar Ranch property, 25 miles east of Grants and north of Laguna, N. Mex., by the Reserve Oil and Minerals Corp.-Sohio Petroleum Co. joint venture. Here, mining was expected to start in 1974.

Table 4.—Recoverable U_3O_8 mine production. by State[1]

(Thousand pounds U_3O_8 and thousand dollars)

State	1971		1972		1973 [e]	
	Quantity	Value [e]	Quantity	Value [e]	Quantity	Value
Colorado	2,536	15,725	1,877	11,825	1,920	12,480
New Mexico	10,567	65,517	10,808	68,091	9,140	59,410
Utah	1,445	8,959	1,496	9,425	1,940	12,610
Wyoming	6,986	43,311	8,544	53,827	10,060	65,390
Other [2]	2,981	18,484	3,033	19,104	2,760	17,940
Total	24,515	151,996	25,758	162,272	25,820	167,830

[e] Estimate.
[1] Based on mill recovery factors and estimated average market price per pound U_3O_8. Does not include uranium recoverable in miscellaneous operations (leach, mine waters, and raffinate).
[2] Alaska, South Dakota, Texas, and Washington in 1971 and 1972; Alaska, Texas, and Washington in 1973; combined to avoid disclosing individual company confidential data.

In Wyoming, most new mining activity was in the Powder River Basin. Kerr-McGee Corp. was sinking a 950-foot shaft and also planned open pit development 25 miles northwest of Douglas, Converse County. Exxon Corp. started production in 1972 at its nearby Highland open pit and sank a 670-foot shaft which will serve two mines. Production started in September at the open pit of Teton Exploration Drilling Co., Inc., a subsidiary of United Nuclear Corp., near the Highland mine. Teton ore was shipped to the Exxon mill.

In the Crooks Gap district, 10 miles south of Jeffrey City, Wyo., Western Nuclear, Inc., started shaft-sinking for a 1,500-ton-per-day mine. The company reported recoverable reserves at 11.5 million pounds U_3O_8.

Numerous small mines were closed in Colorado during the year. Susquehanna Corp. closed its mines and disposed of its uranium interests in Falls City and Ray Point, Tex.

TVA secured interests in two significant mining ventures.[8] TVA leased all mining rights of Federal-American Partners in the Gas Hills district, Wyo., and acquired rights to the mill output after existing contracts are completed. TVA also purchased an interest, with options, in United Nuclear Corp.'s properties in Wyoming and New Mexico.

With uranium prices rising, the commercial recovery of byproduct uranium from wet process phosphoric acid (WPPA) fertilizer operations in central Florida approached economic viability. Uranium Recovery Corp. (URC) planned uranium recovery in 1975 from a modular unit adjoining a W. R. Grace & Co. fertilizer plant, 40 miles east of Tampa, and a central processing plant. which would treat the uranium-bearing solution following initial separation, near Mulberry, Fla. Capacity of the first plant would be 300,000 pounds U_3O_8 per year. In November, United Nuclear Corp. exercised an option to purchase an 85% interest in URC.[9] A number of companies were studying the recovery of uranium from WPPA operations. The phosphate rock in central Florida contains 0.01 to 0.02% U_3O_8, and approximately 1 pound U_3O_8 is recoverable per ton of P_2O_5. Larger WPPA operations could produce 1,500 to 2,000 tons of U_3O_8 per year. According to the AEC, this uranium would be

[7] U.S. Atomic Energy Commission, Grand Junction Office. Statistical Data of the Uranium Industry. GJO-100(74), Jan. 1, 1974, 67 pp.
[8] Atomic Industrial Forum. TVA and Carolina Power and Light in Long-Term Ore Commitments. Nuclear Ind., v. 20, No. 5, May 1973, p. 26.
[9] Mining Congress Journal. United Nuclear Corp. Has Exercised its Option. V. 59, No. 12, December 1973, p. 12.

commercial at a U_3O_8 price of $10 to $15 per pound and as much as 70,000 tons U_3O_8 may be produced from Florida phosphates by the year 2000.

Mill.—Mill production increased slightly during 1973, although operable capacity was reduced by the closing of Susquehanna Corp.'s two mills in Texas. At yearend, capacity was 28,550 tons of ore daily and 18,000 tons U_3O_8 per year. Mill throughput averaged 18,400 tons per day, about 65% of the yearend capacity.[10] Rio Algom Mines, Ltd., was considering a mill expansion to 700 tons of ore per day and 1.7 million pounds U_3O_8 per year. Western Nuclear, Inc., planned to close its mill in Wyoming for expansion to 1,400 tons per day during 1974 and 1975. Exxon's mill in the Powder River Basin, Wyo., may also undergo expansion. New mills were planned by Kerr-McGee Corp. in the Powder River Basin and by Reserve Oil-Sohio Petroleum (1,000 to 1,200 tons per day) at its new mine near Laguna, N. Mex.

Table 5.—Domestic uranium mill statistics in 1973

(Short tons U_3O_8 unless otherwise specified)

Operating mills ---------- number--	18
Average daily milling rate tons of ore--	22,500
Mill receipts, content of ore ----------	13,558
Mill feed:	
Content of ore ----------	13,716
Other [1] ----------	260
Total ----------	13,976
Recovery rate ---------- percent--	93
Production ----------	13,235
Shipments ----------	11,698
Stocks:	
Content of ore, Jan. 1, 1973 ----------	271
Content of ore, Dec. 31, 1973 ----------	113
Concentrate, Jan. 1, 1973 ----------	3,701
Concentrate, Dec. 31, 1973 ----------	5,238
In process:	
Concentrate, Jan. 1, 1973 ----------	468
Concentrate, Dec. 31, 1973 ----------	328

[1] Concentrate from leaching operations, mine waters, refinery residues, recycled tailings, and cleanup.

Source: U.S. Atomic Energy Commission.

Nuclear Fuel Materials.—*Uranium Hexafluoride.*—U_3O_8 to UF_6 conversion capability was available at two plants—Allied Chemical Corp. at Metropolis, Ill. (14,000 tons uranium per year) and Kerr-McGee Corp. at Sequoyah, Okla. (5,000 tons uranium per year). The latter capacity will be doubled, although dates have not been announced.

Enriched Uranium.—During 1973 the AEC received revenues of $550.5 million for providing 3.56 million separative work units (SWU) to domestic customers and 12.93 million SWU to foreign customers. At yearend, the AEC had contracts for enrichment services with 32 domestic and 41 foreign customers.[11] A total of 10.3 million SWU were produced at the AEC's three gaseous-diffusion enrichment plants in fiscal 1973. This output was at about 60% of rated capacity. The planned Cascade Improvement Program (CIP) will add 5.8 million SWU capacity with no increase in power operating levels, and the Cascade Uprating Program (CUP) will add 4.7 million SWU capacity by increasing the total power level from the present 6,060 megawatts (MW) to 7,380 MW.[12] During the year, the AEC contracted for an average of 957 MW per year, and negotiations were underway for the remaining power needed for the full uprated capacity.

Projected CIP–CUP increases in addition to enriched uranium preproduced from the AEC U_3O_8 stockpile were expected to provide sufficient supplies until 1983.[13] Thereafter, new enrichment capacity, probably by private development, will be needed and, because of the long lead time from planning to operation, the commitment to a firm program by 1976 appeared urgent. Decisions would be necessary on contracts with private industry for enrichment plant, construction, the type and capacity of these plants, power sources, and financing in the billions of dollars. The AEC estimated that the capital cost for one 8.75-million-SWU diffusion plant, the minimum commercial size considered feasible, would be in excess of $1 billion. Other deterrents to private investment in enrichment were; competition from existing AEC facilities and subsidized foreign facilities, the future development of breeder reactors which would reduce demand for enrichment services, and a slow return on investment.[14]

Amendments to the AEC's Domestic Access Program, designed to encourage private domestic development of enrichment capacity, provide for availability of classified

[10] Atomic Industrial Forum. Nuclear Ind., v. 21, No. 2, February 1974, p. 37.

[11] Page 96 of work cited in footnote 2.

[12] U.S. Atomic Energy Commission. The Nuclear Industry. WASH–1174(73), April 1974, pp. 42–49.

[13] U.S. Atomic Energy Commission, Oak Ridge Operations Office. New Enrichment Plant Scheduling. ORO–735, November 1973, 23 pp.

[14] Chemical and Engineering News. Who Will Produce Enriched Uranium? V. 51, No. 49, Dec. 3, 1973, p. 8.

Table 6.—Domestic uranium milling companies and plants in 1973

Company	Plant location	Capacity (tons of ore per day)
The Anaconda Company	Bluewater, N. Mex	3,000
Atlas Corp	Moab, Utah	[1] 1,500
Continental Oil Co.—Pioneer Nuclear, Inc	Falls City, Tex	1,750
Cotter Corp	Canon City, Colo	450
Dawn Mining Co	Ford, Wash	500
Exxon Co	Powder River Basin, Wyo	2,000
Federal Resources Corp.—American Nuclear Corp	Gas Hills, Wyo	950
Kerr-McGee Corp	Grants, N. Mex	7,000
Petrotomics Co	Shirley Basin, Wyo	1,500
Rio Algom Mines, Ltd	La Sal, Utah	500
Susquehanna-Western, Inc	Falls City, Tex	[2] 1,000
Do	Ray Point, Tex	[2] 1,000
Union Carbide Corp	Uravan, Colo	1,300
Do	Natrona County, Wyo	1,000
United Nuclear Corp. Inc.—Homestake Mining Co	Grants, N. Mex	3,500
Utah International, Inc	Gas Hills, Wyo	1,200
Do	Shirley Basin, Wyo	1,200
Western Nuclear, Inc	Jeffrey City, Wyo	1,200
Total		30,550

[1] On standby at yearend.
[2] Closed during the year.

Source: U.S. Atomic Energy Commission.

AEC enrichment technology to approved private companies without the commitment of the participant to a research and development program.[15] The first permit was granted to Uranium Enrichment Associates (UEA), a joint venture of Bechtel Corp., Union Carbide Corp., and Westinghouse Electric Corp., which planned to evaluate diffusion and centrifuge technology and establish an enrichment plant. For the use of AEC-developed technology, the AEC would receive a 3% royalty on gross receipts during the first 17 years of commercial operation.[16]

The AEC studied the economics of diffusion and centrifuge technology. For electric power costs at 10 mills per kilowatt-hour and various amortization and other financial assumptions, enrichment services based on the centrifuge range from direct comparability with diffusion technology to cost levels nearly $20 per SWU lower.[17] Under the Centrifuge Development Program, the AEC was building a 25-SWU-per-year test facility at Oak Ridge, Tenn., and planned to spend $117 million through fiscal 1975. Access to classified data, under the Industrial Participation Program, was granted to seven companies in addition to the UEA joint venture.[18] General Electric Co. and Exxon Nuclear Corp. started a three-phase joint study on centrifuge enrichment.[19]

The AEC's new enrichment contracting policy, sent to the Joint Committee on Atomic Energy in January, became effective May 9. Contracting was suspended while AEC considered the reactions of domestic and foreign customers. The new fixed commitment contracting procedure replaced the old requirements-type contracts.[20] Late in the year, there was a flurry of new contracting activity involving 25 new domestic customers and 36 new foreign customers.

Fabrication.—The AEC reported the quantities of enriched UF_6 shipped to domestic and foreign nuclear fuel fabricators, in thousand SWU, as follows:[21]

Fiscal year	Domestic	Foreign
1972	1,266	356
1973	1,466	779

This does not include shipments for domestic test reactors and Navy programs.

[15] Federal Register. Permits for Access to Restricted Data Concerning the Separation of Uranium Isotopes. V. 38, No. 84, May 2, 1973, pp. 10803–10805.

[16] Atomic Industrial Forum. Broad Enrichment Access Instituted; First Applicant Approved. Nuclear Ind., v. 20, No. 5, May 1973, p. 27.

[17] Atomic Industrial Forum. Phase I Enrichment Hearings Warn: This Road May Lead Nowhere. Nuclear Ind., v. 20, No. 8, August 1973, pp. 6–9.

[18] Chemical and Engineering News. AEC Presses Gas Centrifuge Program. V. 51, No. 24, June 11, 1973, p. 16.

[19] American Nuclear Society. Emphasize Gas Centrifuge in Joint Investigation. Nuclear News, v. 16, No. 11, September 1973, p. 65.

[20] Atomic Industrial Forum. Radical Changes in Enrichment Contracting Ground Rules. Nuclear Ind., v. 20, No. 1, January 1973, pp. 13–14.

[21] Page 50 of work cited in footnote 12.

The demonstration LMFBR fuel core was expected to have 43,000 fuel pins in 198 fuel assemblies, which had not been ordered at yearend.

The AEC estimated fabrication costs for mixed oxide (U–Pu) FBR fuels at $6,000 to $8,000 per kilogram of contained Pu during the next few years.

Table 7 lists the 14 companies engaged in commercial fabrication of UO_2, carbide, special, Pu, and U_{233} fuels at 21 plants.

Table 7.—Principal nuclear fuel processing and production facilities in 1973

Company	Location	Product or service
Allied Gulf Nuclear Services, Inc	Barnwell, S. C	Reprocessing;[1] conversion enriched U to UF_6.[1]
Allied Chemical Corp	Metropolis, Ill	UF_6.
Babcock and Wilcox Co	Lynchburg, Va	UO_2;[1] UO_2 pellets;[1] fabrication of UO_2 and Pu fuels.
Combustion Engineering Co	Windsor, Conn	UO_2;[1] UO_2 pellets; fabrication of UO_2 and Pu[1] fuels.
Exxon Nuclear Corp	Richland, Wash	Reprocessing;[1] UO_2; UO_2 pellets; fabrication of UO_2 and Pu fuels; U[1] and Pu scrap.[1]
General Atomic Co	San Diego, Calif	Fabrication of carbide and special fuels.
Do	Youngsville, N. C	Fabrication of carbide[1] and special fuels.[1]
Do	[2]	Reprocessing;[1] fabrication of U_{233} fuels.[1]
General Electric Co	Morris, Ill	Reprocessing;[1] conversion enriched U to UF_6.[1]
Do	San Jose and Vallecitos, Calif	Fabrication of Pu fuels; U and Pu scrap.
Do	Wilmington, N. C	UO_2; UO_2 pellets; fabrication of UO_2 fuels; U scrap.
Goodyear Atomic Corp[3]	Portsmouth, Ohio	Enriched UF_6.
Gulf United Nuclear Fuels Corp	Elmsford and Pawling, N.Y	Fabrication of carbide and Pu fuels; Pu scrap.[1]
Do	Hematite, Mo	UO_2; UO_2 pellets; fabrication of carbide fuels; depleted U compounds.
Do	New Haven, Conn	Fabrication of UO_2 and special fuels; depleted U metal.
Kerr-McGee Corp	Cimarron, Okla	UO_2; UO_2 pellets; fabrication of UO_2, carbide, special, and Pu fuels; depleted U metal and compounds; U and Pu scrap.
Do	Sequoyah, Okla	UF_6.
NL Industries, Inc	Albany, N. Y	Depleted U metal.
North American Rockwell Corp., Atomics International Div	Canoga Park, Calif	Fabrication of carbide, special, and Pu fuels; depleted U compounds and metal; Pu scrap.[1]
Nuclear Chemical and Metals Corp	Huntsville, Tenn	Fabrication of carbide fuels; depleted U metal[1] and compounds; U scrap.[1]
Nuclear Fuel Services, Inc	Erwin, Tenn	UO_2; UO_2 pellets; fabrication of carbide, U_{233}, and Pu fuels; depleted U metal and compounds; U and Pu scrap.
Do	West Valley, N. Y	Reprocessing;[4] enriched U to UF_6.[1]
Nuclear Materials and Equipment Corp. (NUMEC)	Apollo, Pa	UO_2; UO_2 pellets; fabrication of UO_2 fuels; depleted U compounds; U scrap; highly enriched U to UF_6.
Do	Leechburg, Pa	Fabrication of carbide; special, U_{233}, and Pu fuels; depleted U metal; Pu scrap.
Tennessee Nuclear Specialties, Inc	Jonesboro, Tenn	Depleted U metal and compounds.
Texas Instruments, Inc	Attleboro, Mass	Fabrication of special fuels.
Union Carbide Corp[3]	Oak Ridge, Tenn	Enriched UF_6.
Do[3]	Paducah, Ky	Do.
United Nuclear Corp	Wood River Junction, R. I	U scrap.
United States Nuclear Corp	Oak Ridge, Tenn	Fabrication of special fuels.
Westinghouse Electric Corp	Cheswick, Pa	UO_2 pellets; fabrication of UO_2, carbide, and Pu fuels; Pu scrap.
Do	Columbia, S. C	UO_2; UO_2 pellets; fabrication of UO_2 fuels; U scrap.[1]
Do	Anderson, S. C	Fabrication of Pu fuels;[1] Pu scrap.[1]
Whittaker Corp., Nuclear Metals Div	West Concord, Mass	Fabrication of special fuels; depleted U metal.

[1] Under construction or planned.
[2] Not determined.
[3] Contractor for U.S. Atomic Energy Commission.
[4] On standby.
Source: U.S. Atomic Energy Commission.

Reprocessing.—Until December 31, 1977, AEC reprocessing facilities will be available for spent fuels from research and test reactors and other reactors for which these services are not available from industry at reasonable terms.

At yearend, three commercial reprocessing plants were under construction, one (Nuclear Fuel Services, Inc., at West Valley. N.Y.) was on standby, and one was planned (by General Atomic Co.) at an undetermined site. Full-scale operation at General Electric's Midwest Fuel Recovery Plant, Morris, Ill., where capacity is 330 short tons of uranium annually, was delayed until 1974. This facility has industry's first waste calciner for high-level materials. Nuclear Fuel Services' plant at West Valley, N.Y., was inactive; it was under modernization and expansion to 830 tons uranium per year and was scheduled for operation in 1977 or 1978. Allied Gulf Nuclear Services, Inc. (AGNS), continued construction on the largest domestic reprocessing plant, at Barnwell, S.C., where annual capacity will be 1,650 tons uranium. AGNS will receive spent fuels in 1974 and start processing in 1975. These companies were seeking contracts for future reprocessing work, but activity was light. Pending problems were short-term spent fuel storage capacity and limited shipping cask capacity. Estimated reprocessing cost was $40,000 per ton, excluding storage at site and canister shipping costs.[22]

Waste Management.—Three domestic commercial waste disposal companies and six burial sites were in operation. It was estimated that the volume of low-level wastes available for burial was 1.5 million cubic feet and will reach 2 million cubic feet in 1975, 4 million cubic feet in 1980, and 6 million cubic feet in 1985. AEC-generated solid wastes were accumulating at a decreasing rate because of a program to reduce the volume of wastes. During 1973, as estimated 1.3 million cubic feet of solid wastes were buried at AEC sites. The AEC estimated that approximately 3,899 cubic feet of significant radioactive wastes were generated annually at a 1,000-MW BWR and about 1,000 cubic feet at a 1,000-MW PWR. Shipments of high-level wastes to Federal repositories were expected to start about 1983, following a 10-year cooling and storage period at the reprocessing site. The AEC planned to build a Retrievable Surface Storage Facility for temporary high-level waste storage pending a final decision on permanent storage.[23] The objective was to improve the economics of waste management and lessen the necessity for surveillance and maintenance. A pilot plant holding 1,000 canisters will be built in a bedded salt formation. Battelle Pacific Northwest Laboratories, Richland, Wash., continued studies on disposal methods.[24] It was estimated that 80,000 waste canisters, measuring 1 by 10 feet, would be in storage by the year 2010.[25]

CONSUMPTION AND USES

According to the AEC, the use of U_3O_8 equivalent in domestic commercial reactors totaled 8,200 tons, a slight increase over that of 1972. Commercial reactor startup continued to be slowed by licensing delays, construction problems, technical failures, and growing shortages of supplies, equipment, and skilled labor. Efforts were made to shorten lead time from the present 8 to 10 years to 7 to 8 years in the short term and 5 to 6 years in the long term by reactor standardization and designated siting procedures.[26]

Although slippages were incurred in commercial reactor plans, new reactor orders and U_3O_8 buying activity were at record levels. A total of 38 nuclear units (42,670 MW) were ordered, compared with 35 units (38,000 MW) in 1972. At yearend, commercial reactor status was as follows:

Status	Number of plants	Capacity (megawatts)
Operable	42	25,024
Under construction	56	53,020
Under contract (reactors ordered)	101	109,735
Total	199	187,779

[22] Atomic Industrial Forum. Reprocessors Seek Work, Utilities Delaying Decisions. Nuclear Ind., v. 20, No. 12, December 1973, pp. 30–33.
[23] Pages 57–65 of work cited in footnote 12.
[24] Atomic Industrial Forum. Pittman Reports on Commercial Waste Management Status. Nuclear Ind., v. 20, No. 8, August 1973, pp. 20–22.
[25] American Nuclear Society. Conference on Reactor Operating Experience. Nuclear News, v. 16, No. 11, September 1973, pp. 96–98.
[26] Chemical and Engineering News. Quicker Startup of Nuclear Plants Sought. V. 51, No. 48, Nov. 26, 1973, pp. 7–8.

Fifteen additional units were planned at yearend, although reactors had not been ordered. During the year, 13 plants (10,341 MW) became operable, and the AEC issued construction licenses for 14 plants at 9 sites.

An AEC U_3O_8 market survey of 64 utility companies, 5 reactor manufacturers, and 20 U_3O_8 producers indicated increased U_3O_8 purchasing activity.[27] U_3O_8 delivery commitments increased substantially for the 1974–80 period; forward commitments of 120,000 tons U_3O_8 at yearend were 33,700 tons U_3O_8 higher than at the beginning of the year. The status, including foreign orders, was as follows, at yearend:

	U_3O_8 (tons)
Deliveries and forward commitments, Jan. 1	129,800
Deliveries and forward commitments, Dec. 31	175,600
Deliveries, through Dec. 31	55,600
Forward commitments, Dec. 31	120,000

The survey also revealed that buyers had contracted for only 68% of first core fuels and progressively less for the annual refueling needs.

Table 8.—Current and projected domestic commercial uranium delivery commitments

(Short tons U_3O_8)

Year	Commitments [1]	
	Annual	Cumulative
1973	12,100	[2] 55,600
1974	13,700	69,300
1975	15,500	84,800
1976	10,900	95,700
1977	11,600	107,300
1978	13,200	120,500
1979	12,100	132,600
1980	10,200	142,800

[1] In the post-1980 period through 1994, an additional 30,300 tons have been committed. In addition, 6,700 tons have been committed to foreign buyers, of which 5,500 tons were delivered prior to yearend 1973.
[2] Pre-1973 deliveries were 43,500 tons.

Source: U.S. Atomic Energy Commission.

Table 9.—Uranium fuel supply arrangements for domestic nuclear reactors [1]

(Percent of total nuclear generating capacity)

Source of Supply	First core	Reloads [2]														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Primary producers	37	33	30	27	21	18	13	10	8	6	3	2	2	2	1	1
Reactor manufacturers	31	29	24	23	17	14	11	9	6	4	4	2	2	2	2	2
Total	68	62	54	50	38	32	24	19	14	10	7	4	4	4	3	3

[1] As of yearend 1973. Includes reactors operating, under construction, and scheduled totaling 188,000 megawatts. Does not include leases from AEC, which are small, comprising less than 0.5% for first cores and for refueling through seventh reload, when they are scheduled to terminate.
[2] Refueling estimated on annual basis.

Source: U.S. Atomic Energy Commission.

AEC estimates for projected U_3O_8 and enriched uranium demands were lower than those of the previous year, owing to the continuing slippages in commercial reactor schedules and to general energy conservation practices. Estimates for probable domestic nuclear capacity, in thousands MW, were as follows:

Year	1972	1973
1980	132	102
1985	280	250
1990	508	475
2000	1,200	1,090

Short-term U_3O_8 demand, during 1974–80, was correspondingly lower. Cumulative demand in 1980 was nearly 45,000 tons U_3O_8 below the earlier estimate. Projected demand for enrichment services was also affected by the reduced estimates for operable nuclear capacity, particularly in the short term.

Table 10.—Current and projected domestic U_3O_8 demand [1]

(Short tons)

Year	Low	High	Probable	
			Annual	Cumulative
1973	6,800	9,600	8,200	8,200
1974	9,700	12,300	11,600	19,800
1975	11,800	14,000	14,100	33,900
1976	12,700	15,900	15,200	49,100
1977	15,500	20,100	19,400	68,500
1978	20,500	26,200	23,900	92,400
1979	26,300	31,600	30,400	122,800
1980	30,300	35,500	37,900	160,700
1985	55,200	70,900	60,400	397,100
2000	119,200	202,700	156,900	2,186,900

[1] 0.30% tails assay; Pu recycle start 1977.

Source: U.S. Atomic Energy Commission.

Late in the year, Offshore Power Systems Inc., jointly owned by Westinghouse Elec-

[27] U.S. Atomic Energy Commission, Division of Production and Materials Management. Survey of United States Uranium Marketing Activity. WASH-1196(74), 23 pp.

Table 11.—Current and projected domestic demand for separative work [1]

(Thousand SWU per year)

Year	Low	High	Probable
1973	2,700	3,700	2,800
1974	2,500	4,600	3,400
1975	5,000	5,600	5,600
1980	11,300	14,200	13,900
1985	23,000	28,500	24,600
2000	57,400	97,400	75,300

[1] Domestic orders only; 0.30% U_{235} tails assay; Pu recycle start in 1977.

Source: U.S. Atomic Energy Commission.

tric Corp. and Tenneco Inc., was negotiating with suppliers and Government officials for a location site for offshore nuclear powerplant construction facilities. The company had selected a plant site near Jacksonville, Fla., and indicated that orders for six offshore reactor units would justify construction. Four units were ordered during the year—two to be located off the New Jersey coast and two off the Mississippi coast.[28] Each complete reactor unit would be barged to its operating site.

In November, the U.S. Maritime Commission received a proposal for construction of a 415,000-deadweight ton, nuclear-powered oil supertanker. The oil industry appeared interested; the proposed tanker could move an estimated 800,000 tons more crude oil per year than the slower conventional tankers of the same capacity.

Late in the year, plans were made to establish a World Nuclear Fuel Market (WNFM), an agency for the buying and selling of uranium and nuclear fuels, with headquarters at Atlanta, Ga. With international competition for uranium and nuclear fuels growing more intense, WNFM would set policies, resolve problems, and provide information on buyers and sellers to its members. Nuclear Assurance Corp. is the founder and coordinator.[29]

Nuclear Fuel Services, Inc., West Valley, N.Y., was granted a license for a cask, made of depleted uranium and of 50,000-pound capacity, for transporting spent fuel assemblies.[30]

[28] American Metal Market. Offshore Nuclear Plants: An Unusual Contract Goes Shopping. V. 80, No. 195, Oct. 8, 1973, p. 4.

[29] Chemical Week. Nuclear Supermarket. V. 114, No. 5, Jan. 30, 1974, p. 15.

[30] Chemical and Engineering News. Cask Readied for Spent Nuclear Fuel. V. 51, No. 8, Feb. 19, 1973, p. 35.

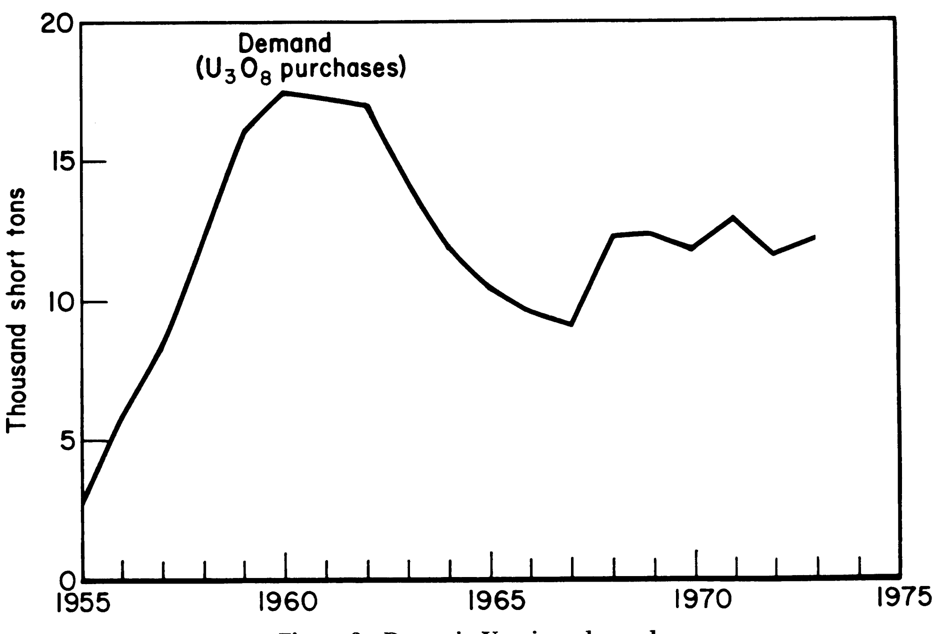

Figure 2.—Domestic Uranium demand.

STOCKS

The AEC reported private inventories at the beginning and end of the year, in tons U_3O_8, as follows:

	Jan. 1, 1973	Dec. 31, 1973
In ore at mills	271	113
In process at mills	468	328
In concentrate at mills	3,701	5,238
In concentrate held by utility companies and reactor manufacturers (includes UF_6)	14,400	19,900
Total	18,840	25,579

On the basis of delivery commitments and forecast demand, inventories were expected to increase to about 28,000 tons U_3O_8 in 1975–76 and decline thereafter.

PRICES

Following several years of depressed markets and soft prices for U_3O_8, the price strengthened during 1973. Whereas spot prices were on the order of $6 to $6.25 per pound U_3O_8 early in the year, they increased to about $7 per pound U_3O_8 at yearend and were expected to escalate further during 1974.

The AEC conducted a survey of prices paid by reactor manufacturers and utility companies, as of January 1, 1973, for existing contracts during 1967–72 and for delivery each year during 1973–80.[31] The price (1973 dollars) ranged from $7.10 per pound for delivery in 1973 to $7.80 for delivery in 1980. The AEC commented that these contracts represented only a small part of projected requirements to 1980, did not reflect higher prices in late 1973, and were not indicative of market prices prevailing throughout the year.

Although domestic and foreign sales contracts were negotiated, sales activity was slow during a period of low prices and an uncertain future. Competitive fixed-price bidding procedures appeared to have ended. Sellers were reluctant to conclude contracts, owing to questions arising on prices at time of future deliveries. Price adjustment clauses and currency shift safeguards were considered in long-term contracts.[32] Canada, Australia, the Republic of South Africa, and France, after several international meetings, established a policy of no price quotations for post-1980 delivery.

Higher prices, averaging about $7 per pound U_3O_8, were indicated in Canadian contracts for delivery to Spain in 1974–77 and to Japan in 1977–81. Reserve Oil and Uranium Co. announced a sale of 5 to 6 million pounds U_3O_8, valued at approximately $50 million, for delivery during 1977–81. In November, Kerr-McGee Corp. sold in excess of 12 million pounds U_3O_8 for more than $150 million for delivery during 1977–85.[33] Western Nuclear Inc. was seeking $12 per pound U_3O_8 for delivery in 1979–80, $14 for delivery in 1981–85, and $16 for delivery in 1986–90, all subject to escalation clauses.

Kerr-McGee Corp. offered UF_6 in specified quantities, also subject to escalation, at $35.95 per pound (equating to $12.10 per pound ($U_3O_8$) for delivery in 1977 and at $44.39 per pound (equating to $15.50 per pound U_3O_8) for delivery in 1982. A revised table of base charges for UF_6 and enriching services was announced by the AEC.[34] Effective August 14, 1973, AEC charges for enrichment services were increased from $32 per SWU to $38.50 per SWU, the third increase within 2½ years, for the old requirements-type contracts. The rate was reduced to $36 per SWU for the new, fixed commitment contracts covering 10 years and for short-term customers. The AEC re-

[31] U.S. Atomic Energy Commission, Grand Junction Office. AEC Surveys United States Uranium Prices. News Release No. 648, Dec. 4, 1973, 2 pp.

[32] Metal Bulletin. Uranium Trade Hotting Up. No. 5830, Sept. 4, 1973, p. 21.

[33] Chemical Week. New Power in Nuclear. V. 113, No. 21, Nov. 21, 1973, p. 15.

[34] Federal Register. Uranium Hexafluoride Charges, Enriching Services, Specifications, and Packaging; Revisions. V. 38, No. 30, Feb. 14, 1973, pp. 4432–4433.

served the right to increase charges by at least 1% each 6 months after January 1, 1974.[35]

Urenco Ltd., the European company representing the United Kingdom-the Netherlands-West Germany enrichment project, announced terms and conditions for its enrichment services by gas centrifuge technology. Initial charges were the equivalent of $48 per SWU, subject to downpayment and price escalation, for minimum 10-year supply contracts.[36]

FOREIGN TRADE

Larger quantities of U_3O_8 concentrate and UF_6 entered the United States for enrichment services and re-export of the enriched product. The AEC had under consideration an amendment to the Uranium Enrichment Services Criteria, established pursuant to subsection 161(v) of The Atomic Energy Act of 1954, as amended.[37] The proposed amendment would remove the existing embargo on the use of foreign uranium in domestic reactors on a graduated basis, starting with 10% of the domestic supply permitted from foreign sources in 1977, 80% permitted in 1983, and no restrictions thereafter.

[35] Atomic Industrial Forum. AEC Decrees Increase of Basic Enrichment Charge to $38.50. V. 20, No. 2, February 1973, p. 21.

[36] Atomic Industrial Forum. Basic URENCO Contracting Conditions. V. 20, No. 9, September 1973, p. 35.

[37] Federal Register. Restrictions on Enrichment of Foreign Uranium for Domestic Use. Notice of Proposed Modification. V. 38, No. 227, Nov. 27, 1973, pp. 32595–32596.

Table 12.—Foreign trade in uranium, uranium-bearing materials, and other nuclear materials, by principal country

Product	1972 Quantity	1972 Value	1973 Quantity	1973 Value	Principal sources and destinations, 1973
EXPORTS					
Uranium:					
Ores and concentrates, U_3O_8 content pounds	151,590	$626,843	109,934	$736,560	All to Canada.
Compounds do	6,714,148	46,614,501	4,028,095	26,107,130	Canada 3,788,776; United Kingdom 195,817; Japan 41,265; Indonesia 1,706.
Metal including alloys [1] do	16,624	291,048	14,737	269,708	Italy 12,071; Japan 1,910; Canada 654.
Isotopes (stable) and their compounds	NA	19,053,518	NA	17,041,107	Canada $12,183,242; Switzerland $3,323,552; West Germany $371,851; France $303,136; Pakistan $237,215; United Kingdom $158,951; Japan $156,792.
Radioactive materials:					
Radioisotopes, elements, and compounds [2] thousand curies	10,409,327	r 8,733,247	15,615,135	12,302,891	Japan 5,586,251; Canada 5,281,299; West Germany 1,037,806; Belgium-Luxembourg 749,821; United Arab Emirates 698,091.
Special nuclear materials [3]	NA	r 104,014,721	NA	223,516,224	Japan $109,168,561; West Germany $46,906,450; Sweden $21,301,132; United Kingdom $11,864,572; France $9,410,428; Switzerland $8,309,324; Italy $6,648,105.
IMPORTS					
Uranium:					
Oxide (U_3O_8) pounds	4,568,033	30,224,696	11,210,066	61,442,214	Canada 9,913,938; Republic of South Africa 1,295,554.
Other compounds do	10,731,091	74,922,171	10,914,684	82,859,653	Canada 4,314,751; United Kingdom 3,607,904; France 2,992,025.
Isotopes (stable) and their compounds	NA	435,155	NA	807,578	Canada $290,028; U.S.S.R. $172,389; United Kingdom $168,025; Israel $59,289; France $39,070.
Radioactive materials:					
Radioisotopes, elements, and compounds [4] thousand curies	r 22,623,114	r 4,443,321	34,672,001	5,536,645	Canada 31,224,424; Switzerland 2,500,661; United Kingdom 441,111; West Germany 194,705; Sweden 171,044.

r Revised. NA Not available.
1 Includes thorium.
2 Includes carbon-14 and cobalt-60.
3 Includes plutonium, uranium-233, uranium-235, and enriched uranium.
4 Includes cobalt-60.

WORLD REVIEW

International maneuvering continued on a large scale in attempts to negotiate agreements for development of mine, mill, enrichment, and nuclear fuel facilities. New mines and mills were under development or planned in Australia, Canada, Niger, and the Territory of South-West Africa. Progress was made in gas centrifuge technology as an alternative to gaseous diffusion for uranium enrichment. The industrialized uranium-consuming nations conducted negotiations among themselves and with the uranium-producing nations for new enrichment capacity, which will be needed after 1980.

The tripartite project (West Germany, United Kingdom, and the Netherlands) for commercial development of centrifuge enrichment announced plans for two semicommercial-scale plants, each of 200,000 SWU, at Capenhurst (United Kingdom) and Almelo (the Netherlands).[38] The estimated initial cost for enrichment services was expected to be $48 per SWU, considerably higher than current costs. Urenco Ltd., the operating and marketing company, sponsored the Association for Centrifuge Enrichment (ACE), a multinational study group comprising 14 organizations in 11 countries.[39]

Demand for enriched uranium in Western Europe was 2.5 million SWU and was projected at 9 million SWU in 1980 and 21 million SWU in 1985. Urenco capacity was expected to be 2 million SWU in 1980 and 10 million SWU in 1985. Eurodif, an association sponsored by the French and based on gaseous diffusion enrichment, planned capacity of 10 million SWU in 1980.[40]

European Communities (EC) goals were directed toward reduction of dependence on the USAEC for enrichment services. The EC planned capacity of 3,000 to 4,000 SWU by 1981 as well as Urenco's 10 million SWU in 1985. A standing committee was established to develop a coordinated enrichment industry in Europe through market surveys and technical-economic analysis. The EC's Permanent Council wanted 70% of total requirements for enriched uranium produced within the EC by 1985, when full competitiveness with other producers was anticipated.[41] The status of power reactor development among the nine EC member countries, as of January 1. 1973, was as follows: Operable, 10,906 MW; under construction, 15,485 MW; and ordered or planned, 17,624 MW, for a total of 44,015 MW.[42] Projected EC capacity was 60,000 MW in 1980 and 133,000 MW in 1985. Because of possible future shortages of enriched uranium before sufficient capacity has been developed, the allocation from the United States was increased from 215,000 SWU to 583,000 SWU in August.

The International Atomic Energy Agency (IAEA) of the United Nations conducted power reactor surveys, sponsored feasibility studies, organized technical meetings, awarded training fellowships, and published a variety of international nuclear industry reports. A nuclear power market survey of developing nations during 1980–90 indicated the possibility of 164 nuclear plants (85,000 MW) in 10 countries as a low estimate and 412 plants (120,000 MW) in 53 countries as a high estimate.[43]

A study of the worldwide status of nuclear reactor development plans, made by the American Nuclear Society, indicated that 374 installations (262,754 MW) were in operation, under construction, and ordered, in 26 countries at midyear 1973.[44] About 47% of the total number of plants and 61% of the capacity were in the United States.

The NEA/IAEA Working Party projected non-Communist world nuclear capacity to 1985. Capacity involving 32 nations was expected to increase more than tenfold from 1973 to 1985. The United States, which had 56% of total capacity in 1973, would account for about one-half of total capacity in 1980 and 1985. The five leading nations (United States, Japan, West Germany,

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[38] American Nuclear Society. Urenco Starts Talks on Centrifuge Plant. Nuclear News, v. 16, No. 13, October 1973, pp. 59–60.

[39] Atomic Industrial Forum. U.S. Firms Can Join European Centrifuge Study's First Phase. Nuclear Ind., v. 20, No. 2, February 1973, pp. 51–52.

[40] The Economist. Now the Heat Is On, Who Will Supply Europes Uranium? V. 249, No. 6782, Oct. 27, 1973, pp. 75–76.

[41] Metal Bulletin. EEC Uranium. Enrichment Plans. No. 5859, Dec. 14, 1973, p. 6.

[42] American Nuclear Society. Nuclear Status for Enlarged Community. Nuclear News, v. 16, No. 2, February 1973, pp. 47–48.

[43] Wilson, J. R. Extended Study of the Potential Market for Nuclear Power in the Developing Countries. State Department Airgram A-633, U.S. Mission, IAEA, October 1973, 42 pp.

[44] American Nuclear Society. World List of Nuclear Power Plants. Nuclear News, v. 16, No. 11, pp. 53–66.

Table 13.—World status of nuclear reactor powerplant development[1]

Country	Number of installations	Reactor types[2]	Total capacity (megawatts electric)	Development status (number of plants)		
				Operational	Under construction	Ordered
Argentina	2	PHWR	919	--	1	1
Austria	1	BWR	692	--	--	1
Belgium	3	PWR	1,650	--	3	--
Brazil	1	PWR	626	--	1	--
Bulgaria	4	PWR	1,760	--	2	2
Canada	11	PHWR, BWR	6,084	6	4	1
Czechoslovakia	5	PWR, GCHWR	1,870	1	--	4
Finland	3	PWR, BWR	1,500	--	2	1
France	17	PWR, GCR, BWR, GCHWR, LMFBR.	8,594	11	4	2
Germany, East	5	PWR	1,835	1	4	--
Germany, West	20	PWR, BWR, THTR, PHWR, GCHWR, LMFBR.	14,479	7	12	1
Hungary	2	PWR	880	--	--	2
India	7	PHWR, BWR	1,388	4	2	1
Italy	5	BWR, PWR, GCR, LWCHR.	1,427	3	2	--
Japan	24	BWR, PWR, GCR, HWLWR, LMFBR.	15,603	6	18	--
Korea, Rep. of	1	PWR	564	--	1	--
Mexico	1	PWR	600	--	1	--
Netherlands	2	BWR, PWR	505	2	--	--
Pakistan	1	PHWR	125	1	--	--
Spain	10	PWR, BWR, GCR.	7,411	3	6	1
Sweden	10	BWR, PWR	7,349	1	5	4
Switzerland	6	BWR, PWR	3,676	3	2	1
Taiwan	4	BWR	3,110	--	2	2
United Kingdom	39	GCR, AGR, HWLWR, LMFBR.	11,781	29	10	--
United States	174	PWR, BWR, HTGR, LMFBR, LGR.	159,917	36	55	83
U.S.S.R	16	LGR, PWR, LMFBR.	8,409	10	6	--
World total	374		262,754	124	143	107

[1] As of June 30, 1973.
[2] AGR—Advanced Gas-Cooled Reactor; BWR—Boiling Water Reactor; GCHWR—Gas-Cooled Heavy Water Reactor; GCR—Gas-Cooled Reactor; HTGR—High Temperature Gas-Cooled Reactor; HWLWR—Heavy-Water (moderated) Light-Water (cooled) Reactor; LGR—Light (water) Graphite Reactor; LMFBR—Liquid Metal Fast Breeder Reactor; PHWR—Pressurized Heavy Water Reactor; PWR—Pressurized Water Reactor; THTR—Thorium High Temperature Reactor.

Source: American Nuclear Society.

United Kingdom, and France) would have about 80% of total capacity in those years.

Among the nine Communist nations of Eastern Europe, there would be 40,000 MW of nuclear capacity in 1980 and 160,000 MW in 1990. In these nations, nuclear power was expected to provide one-third of the electric power supply in the year 2000.

Australia.—Although there was no production of uranium during the year, a number of major new mines were under development, and new mills for production of uranium concentrate were planned. In the East Alligator River district, annual capacity of 5,000 tons U_3O_8 was anticipated from three operations by 1980. However, announced new Government policies concerning foreign participation in uranium ventures and uranium exports tended to reduce development activity. The Minister for Minerals and Energy announced plans to fulfill existing contract commitments but prohibited new export contracts, pending a new energy policy. Existing export contracts totaled 11,522 tons U_3O_8 for delivery during 1974–86 from three mines—Mary Kathleen Uranium Ltd., Ranger Uranium Mines (Pty.) Ltd., and Queensland Mines Ltd. At one point the Government considered supplying uranium for existing contracts from only the Mary Kathleen deposit in Queensland, which has been inactive since 1964 but maintained on a standby basis, and reserving production

Table 14.—Projected world nuclear capacity [1]

(Megawatts Electric)

Country	1973	1974	1975	1976	1977	1978	1979	1980	1985
Austria	--	--	--	700	700	700	1,400	1,400	3,000
Australia	--	--	--	--	--	500	500	1,000	3,000
Belgium	400	1,300	1,700	1,700	1,700	2,300	2,300	3,000	5,500
Canada	2,500	2,500	2,500	3,300	4,000	4,800	5,500	6,500	15,000
Denmark	--	--	--	--	--	--	--	700	1,500
Finland	--	--	--	400	400	400	800	1,300	4,600
France	2,800	3,200	3,800	4,400	6,800	8,900	10,700	13,400	32,500
Germany, West	2,100	4,900	4,900	9,300	11,500	13,500	16,000	19,000	38,000
Greece	--	--	--	--	--	--	--	700	1,500
Italy	600	600	1,500	1,500	1,500	2,500	3,500	6,000	18,000
Japan	3,100	5,200	8,600	12,600	17,300	20,600	24,500	32,000	60,000
Netherlands	500	500	500	500	500	1,100	1,100	1,700	3,700
Norway	--	--	--	--	--	--	--	1,000	2,000
Portugal	--	--	--	--	--	--	--	--	2,000
Spain	1,100	1,100	1,100	2,500	4,200	6,000	6,000	8,000	12,000
Sweden	400	2,600	3,200	3,200	4,100	5,000	6,800	8,300	16,000
Switzerland	1,000	1,000	1,000	1,000	1,000	1,900	1,900	2,600	8,000
Turkey	--	--	--	--	--	--	--	400	1,000
United Kingdom	7,000	7,600	8,800	10,700	11,300	11,300	12,500	13,800	35,000
United States	28,900	42,300	54,200	61,200	69,300	86,700	103,300	132,000	280,000
Other	1,000	1,200	2,000	3,000	4,000	6,100	8,200	11,000	25,000
Total	51,400	74,000	93,800	116,000	138,300	172,300	205,000	263,800	567,300

[1] Total installed capacity at yearend; non-Communist nations only.

Source: OECD Nuclear Energy Agency and International Atomic Energy Agency.

from Northern Territory mines until uranium prices firm up and a more favorable world market exists. Late in the year, the Government proposed development of the Ranger 1 mine in the Northern Territory to meet existing contracts.[45]

As a result of Government restrictions, Western Mining Corp. Ltd. (WMC) planned no further exploration and development at the Yeelirree deposit in Western Australia. Queensland Mines Ltd. suspended further development at Narbarlek, Northern Territory, because of concern with lease renewal in an aboriginal reserve. The purchase of a 10% interest in the Ranger 1 deposit by Ente Nazionale Idrocarburi (ENI) of Italy was subject to approval by the Government.[46]

Studies were underway for future uranium enrichment facilities in Australia. Research and development continued on the gas centrifuge. A preliminary feasibility study on a gaseous diffusion plant in Australia, using French technology, was made jointly with the Commissariat à l'Énergie Atomique (CEA). Possible sites, costs, resource requirements, and potential markets were considered. Australia joined the Association for Centrifuge Enrichment.

Canada.—Large uranium resources, a changing world energy market, growing world demand for uranium, and anticipated higher future prices, triggered new legislative policy proposals, limiting foreign ownership of uranium mines. One proposal limited ownership of Canadian enterprises to 10% by single foreign companies and 33⅓% by foreign company groups.

Table 15.—Uranium oxide (U_3O_8) concentrate: World production, by country

(Short tons)

Country [1]	1971	1972	1973 p
Argentina	r 42	41	42
Canada	4,107	4,885	e 4,800
France	[2] 1,935	1,940	e 1,950
Gabon	601	577	712
Niger	474	956	1,045
Portugal e	105	105	105
South Africa, Republic of	4,189	4,000	3,411
Spain	103	141	106
Sweden e	80	80	80
United States	12,273	12,900	13,235
Total	r 23,909	25,625	25,486

e Estimate. p Preliminary. r Revised.

[1] In addition to the countries listed, Czechoslovakia, Finland, East Germany, West Germany, Hungary, India, Japan, People's Republic of China, and the U.S.S.R. are believed to have produced uranium oxide, but information is inadequate to make reliable estimates of output levels.

[2] Produced in part from imported material.

Mine and mill production varied only slightly from that of 1972. Three operations remained active, two in the Elliot Lake district, Ontario and the other at Eldorado, Saskatchewan. A total of 4,660 tons U_3O_8 concentrate was shipped during the year.[47]

[45] Metal Bulletin. Re-Sell Ranger Uranium Plan. No. 5858, Dec. 11, 1973, p. 21.

[46] Engineering and Mining Journal. ENI to Purchase 10% of Ranger 1. V. 174, No. 6, June 1973, p. 196.

[47] Williams, R. M. Uranium. Can. Min. J., v. 95, No. 2, February 1974, p. 110.

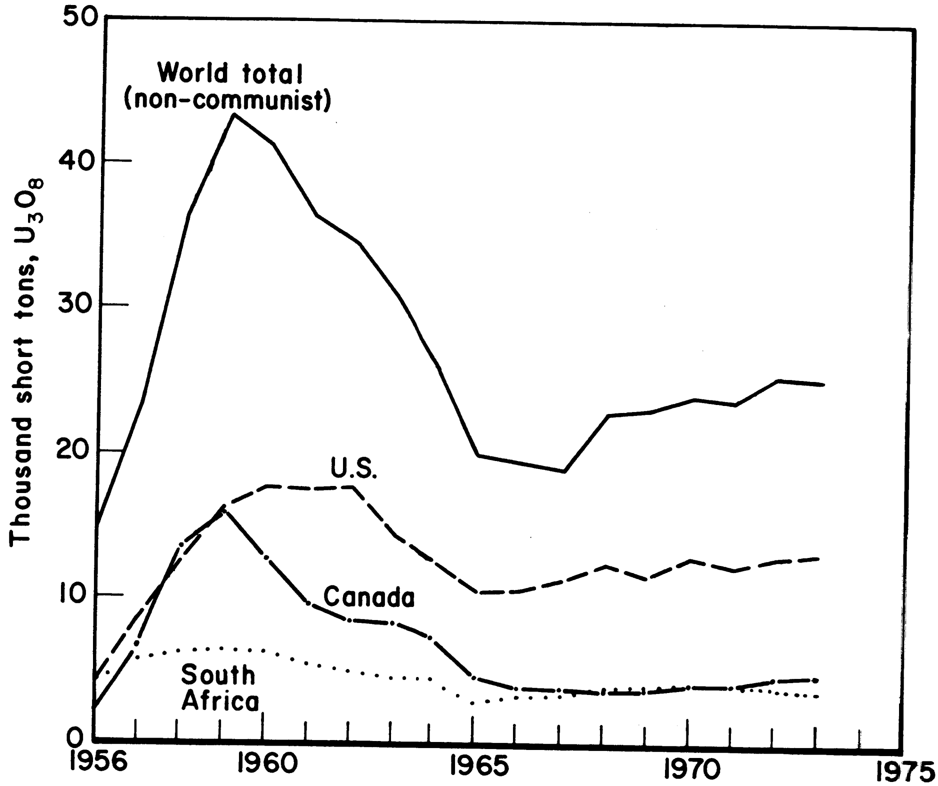

Figure 3.—World (non-Communist) production of uranium concentrate (U_3O_8).

Programs were in progress to increase production capacity. Denison Mines Ltd. was developing a new section of its mine and started mill expansion at Elliot Lake, where throughput capacity will be increased from 4,400 to 7,100 tons of ore per day and annual mill capacity to 10 million pounds U_3O_8.

Open pit mine development and mill construction was on schedule at Rabbit Lake, northern Saskatchewan, by Gulf Minerals Canada Ltd. (51% interest) and Uranerz Canada Ltd. (49% interest). Production was scheduled for 1975 at a rate of 4.5 million pounds U_3O_8 per year.[48]

A production rate of 14,000 tons U_3O_8 per year was planned for 1980. Canada expected to hold about 20% of the world market.[49] More than 78,000 tons U_3O_8 have been committed to domestic and foreign customers since 1966, and 13,000 tons U_3O_8 have been delivered, according to the Department of Energy, Mines and Resources. Long-term sales contracts for U_3O_8 were sought with utility companies.

The Canadian Government gave support to a proposal by Brinco Ltd., comprising RTZ Corp., Bethlehem Steel Corp., Japanese interests, and public shareholders, for a $1 billion enrichment plant, using U.S. gaseous diffusion technology. Brinco was seeking other partners in the venture.[50]

Late in the year, a $800 million contract was negotiated with Tokyo Electric Power Co., involving delivery of 40 million pounds U_3O_8 during 1984–93.[51] The contract was subject to final approval by the companies involved and the respective Governments.

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[48] Engineering and Mining Journal. V. 174, No. 8, August 1973, p. 148.

[49] Atomic Industrial Forum. Canadian Mining Industry Sees Revival of Exploration Activity. Nuclear Ind., v. 20, No. 10, October 1973, pp. 36–37.

[50] Metal Bulletin. Brinco Enrichment Plan. No. 5840, Oct. 9, 1973, p. 22.

[51] The Northern Miner (Toronto). Denison and Tokyo Electric to Sign Record Uranium Deal. V. 59, No. 37, Nov. 29, 1973, pp. 1, 31.

Table 16.—Uranium mills in Canada

Company	Location	Capacity (tons of ore per day)	Status
Can-Fed Resources Ltd	Bancroft, Ontario	1,500	Inactive.
Denison Mines Ltd	Elliot Lake, Ontario	6,000	Active; expansion to 7,100 tons of ore per day scheduled for 1975.
Eldorado Nuclear Ltd	Eldorado, Sasketchewan	1,800	Active; operating at partial capacity.
Gulf Minerals Canada Ltd	Rabbit Lake, Saskatchewan	2,000	Under construction; scheduled completion 1974.
Preston Mines Ltd	Elliot Lake, Ontario	3,000	Inactive.
Rio Algom Mines Ltd.:			
Nordic	do	3,700	Do.
Panel	do	3,000	Do.
Quirke	do	4,500	Active; operating at full capacity.
Stanrock Uranium Mines Ltd	do	3,000	Inactive; partially dismantled.

Source: Department of Energy, Mines and Resources, Ottawa, Canada.

France.—The CEA continued plans to gradually expand mine and mill production in metropolitan France. Eurodif, a multinational corporation comprising the CEA and Italy, Spain, Belgium, and Sweden announced plans to start construction of a $2.65 billion gaseous diffusion enrichment plant in 1974 at Pierrelatte. This plant was scheduled to provide enrichment services capacity of 5 million SWU in 1980 and 9 million SWU ultimately.[52] The CEA proposed French-Japanese and French-Australian establishment of enrichment facilities in the Pacific area, but no firm agreement was reached.

Péchiney-Ugine-Kuhlmann (PUK), in which Westinghouse holds a 35% interest, formed a nuclear fuel company, Eurofuel, which will provide complete fuel cores and replacement fuels for LWR's and mixed U-Pu fuels.

The 250-MW prototype fast breeder reactor (FBR) Phénix at Marcoule was tested early in the year, went critical in August, reached power production in October, and was operating at full power in the Électricité de France power grid at yearend. The CEA planned a 450-MW type and also a Super Phénix, a 1,200 MW FBR, possibly jointly with West German and Italian participation.[53]

Germany, West.—According to the Ministry of Science and Technology, Bonn, Steag A.G. negotiated with South African authorities concerning a cooperative agreement on uranium enrichment and proposed a study of the economic feasibility of the South African enrichment process.[54]

In October, Rheinisch-Westfaelisches Elektrizitaetswerk A.G. (RWE), West Germany's largest utility company, concluded an agreement with the U.S.S.R. in Moscow for 600,000 SWU of enrichment services during 1974–77. Other U.S.S.R.-West German contracts for enrichment services were expected.[55]

To achieve a goal of 18,000 MW of nuclear power capacity in 1980 and 40,000 MW in 1985, the Government planned to assist in reducing reactor construction time, support German companies in foreign exploration, increase enrichment service purchases, and spend about $2 billion on nuclear research and development during 1973–76. Emphasis would be placed on an accelerated reactor development program, stressing the FBR.

A $322 million initial contract was granted for the West German-the Netherlands-Belgium-Luxembourg, 300-MW prototype FBR, SNR–300, to be built at Kalkar. The installation was scheduled for completion in 1979.

India.—The atomic energy program was delayed by a general economic slowdown. Nuclear powerplant construction was 2 to 3 years behind earlier schedules.

[52] Atomic Industrial Forum. France to Sponsor European Diffusion Plant. Nuclear Ind., v. 20, No. 11, November 1973, pp. 53–54.

[53] American Nuclear Society. Phénix Breeder Demo Goes Critical. Nuclear News, v. 16, No. 13, p. 61.

[54] Mining Journal (London). Uranium Enrichment South Africa/German Cooperation. V. 281, No. 7202, Aug. 31, 1973, p. 173.

[55] Engineering and Mining Journal. West German Companies Go the Soviet Way in Uranium Enrichment. V. 174, No. 12, December 1973, p. 23.

FBR research was conducted at Kalpakkam, near Madras, where an infrastructure has been developed for two existing CANDU-type plants. A 15 to 18 MW FBR of the French Rhapsodie type (but modified for electric power generation) was under construction with CEA technical assistance. Radiometallurgical, radiochemical, fuel processing, and fuel fabrication facilities were planned. Engineering designs for a 250- to 500-MW FBR were under study.

Japan.—The Japanese Government and industry were actively engaged in efforts to develop an assured, adequate supply of natural and enriched uranium. According to the annual report of the Japanese Atomic Energy Commission, nuclear power capacity would reach 32,000 MW in 1980 and 60,000 MW in 1985. Utility companies had made arrangements for delivery of 90,000 tons U_3O_8, considered adequate for most needs until 1985.

The Japanese budget for fiscal 1973 allotted $210 million for nuclear research and development, 15% more than fiscal 1972. Included was $107 million for nucleat power development, mainly the FBR.

The Enrichment Survey Committee (ESC), representing the power and nuclear equipment companies, projected uranium enrichment needs at 4 million SWU in 1980, 9 million SWU in 1985, and 15 million SWU in 1990. The ESC proposed Japanese participation in two or three enrichment plants of four to six such plants that would be needed in the non-Communist world during 1980–85. It also was engaged in a feasibility study with Uranium Enrichment Associates, which comprises Bechtel Corp., Union Carbide Corp., and Westinghouse Electric Corp., for the first private enrichment venture in the United States. The Japanese also discussed enrichment ventures with Canada, France, the U.S.S.R., Australia, and the Republic of South Africa.[56]

A U.S.-Japan agreement assures a 30-year supply for development of 60,000 MW of nuclear capacity. Industrial contracts were subject to negotiations between Japanese utility companies and the AEC. The Japanese planned to rely on U.S. enrichment services to 1980, participate in international enrichment ventures after 1980, and develop a commercial gas centrifuge operation in Japan by 1985.[57] Early in the year, Japanese utilities concluded an agreement with the AEC for 10 million SWU, valued at $320 million, with full delivery by 1981.[58] Nuclear powerplant construction experienced both material and labor shortages. At yearend, 14 plants were under construction and 7 plants were scheduled.

In breeder development, an experimental FBR was scheduled for 1974 and a prototype FBR in 1978.

The Science and Technology Agency decided to establish a semi-Government center responsible for radioactive waste management throughout Japan. The program would include waste storage on land, trial ocean disposal, research and development, and land or sea transport of wastes.

South Africa, Republic of.—The pilot enrichment plant of Uranium Enrichment Corp. of South Africa, Ltd., was scheduled for completion in 1974, and plans were made for a $825 million commercial operation of 2.4 million SWU per year.[59] The company reported that estimated capital investment in the commercial operation would be only 65% of that for a gaseous diffusion plant using U.S. technology because of a higher separation factor and the corresponding need for fewer enrichment stages. However, the South African process apparently requires greater energy consumption per SWU.

South-West Africa, Territory of.—RTZ Corp. concluded a partnership and uranium sales agreement with Total Compagnie Minière et Nucléaire concerning the Rossing mine, near Swakopmund.[60] Total acquired 10% of Rossing Uranium Ltd., the operating company, and will purchase a share of the uranium output after 1980. The open pit mine was scheduled for production in 1976 or 1977.

United Kingdom.—New USAEC contractual terms for enrichment services caused the tripartite nations (United Kingdom jointly with West Germany and the Netherlands) to revise plans for gas centrifuge

[56] Engineering and Mining Journal. Japan Actively Seeking Ways to Forge Ahead With Nuclear Industry. V. 174, No. 6, June 1973, pp. 198–200.

[57] Salaff, S. Japan Turns to Uranium. Far-eastern Econ. Rev., v. 81, No. 35, Sept. 3, 1973, pp. 48–49.

[58] American Nuclear Society. Japan Signs $320 Million Pact. Nuclear News, v. 16, No. 4, April 1973, p. 50.

[59] Atomic Industrial Forum. South Africa Aims to Complete Big Enrichment Plant in Early 80s. Nuclear Ind., v. 20, No. 7, July 1973, p. 33.

[60] Engineering and Mining Journal. Rossing Uranium Gets Partner and Sales Deal. V. 174, No. 8, August 1973, p. 13.

plant development. Scheduled planned pilot-plant capacity may be doubled, reaching 500,000 to 600,000 SWU per year by 1976, and commercial capacity was set at 2 million SWU in 1980 and 10 million SWU in 1985.

The National Nuclear Corp. (General Electric Co. 50%, Government 15%, other private 35%) was organized to assume responsibility for future nuclear powerplant design and construction. Controversy continued over whether to use nuclear plants of U.S. or U.K. design for the next stage of commercial development. The Central Electricity Generating Board announced preference for the LWR steam supply system of U.S. design and proposed ordering 18 reactors in two stages during 1974–83, 9 PWRs of U.S. design during 1974–79, and 9 HTGRs, also of U.S. design, thereafter.[61]

U.S.S.R.—Two contracts were concluded for providing 600,000 SWU of enrichment services for first cores at two 1,300-MW reactors in West Germany. The U.S.S.R. also negotiated with the Swedish Nuclear Fuel Supply Co. and the Swedish Oskarsham utility group for about 300,000 SWU, and options for more, for delivery in 1979–80.

The BN-350 FBR at Shevchenko was the first of commercial size to reach criticality, although it was operated at only partial power.[62]

The Communist nations' Council for Mutual Economic Assistance planned 40,000 MW of nuclear capacity by 1980 and 160,000 MW by 1990 in the Communist nations of Eastern Europe.

WORLD RESOURCES

The Organization for Economic Cooperation and Development reported an increase of 34% in reasonably assured resources at $10 per pound U_3O_8, compared to estimates made in 1970.[63] Total resources ($10-per-pound category), including estimated additional resources, also increased by approximately one-third. Major new reserves and resources in Australia, Niger, and the Territory of South-West Africa accounted for a large part of these expanded resources.

Table 17.—World resources of uranium[1]
(Thousand tons U_3O_8)

Country	Resources: Reasonably assured	Resources: Estimated additional
Argentina	12	18
Australia	92	102
Brazil	--	3
Canada	241	247
Central African Republic	10	10
Denmark (Greenland)	7	13
France	47	31
Gabon	26	6
Niger	52	26
Portugal	9	8
South Africa, Republic of [2]	263	10
Spain	11	...
United States	337	700
Yugoslavia	8	13
Other	11	4
Total	1,126	1,191

[1] Non-Communist world only; price range up to $10 per pound U_3O_8; data as of Jan. 1, 1973.
[2] Includes Territory of South-West Africa.

Source: OECD Nuclear Energy Agency and International Atomic Energy Agency.

In Australia, exploration for uranium by national companies and multinational consortia continued at a fast pace, although reduced from the previous year because of announced Government policies. Discoveries were reported in the Northern Territory, South Australia, and Western Australia. Uranium reserves were expected to expand further as exploration and development drilling continued. According to the Australian Atomic Energy Commission (AAEC), reasonably assured resources recoverable at a maximum of $10 per pound U_3O_8 had increased to 140,000 tons at midyear.[64] The AAEC reported resources, as of June 30, 1973, as follows (in thousand tons U_3O_8):

	Less than $10 per pound U_3O_8	$10–$15 per pound U_3O_8
Reasonably assured	140	83
Estimated additional	48	43

In the East Alligator River district, Northern Territory, where a large part of Australia's total uranium resources have

[61] Metal Bulletin. New U.K. Reactors. No. 5862, Dec. 28, 1973, p. 21.
[62] Atomic Industrial Forum. Overseas LMFBRs Moving on Parallel Courses to Full Power Goal. Nuclear Ind., v. 20, No. 8, August 1973, pp. 39–40.
[63] Organization for Economic Cooperation and Development. Uranium Resources, Production and Demand. A joint report by the OECD Nuclear Energy Agency and the International Atomic Energy Agency. August 1973, 140 pp.
[64] Australian Atomic Energy Commission. Twenty-first Annual Report, 1972–73, August 1973, p. 10.

been discovered in recent years, Peko-Wallsend Ltd. and Electrolytic Zinc Industries Ltd. continued evaluation of the Ranger group, 130 miles east of Darwin. In the Ranger 1 anomaly area, reserves were reported at 51,500 tons U_3O_8 (Jabiru ore body) and 31,000 tons U_3O_8 (Jacana ore body). Other localities in the Ranger area were under investigation. Queensland Mines Ltd. reevaluated earlier exploration data and continued exploration in the vicinity of the Nabarlek deposit, where reserves remained unchanged at 10,500 tons U_3O_8. Noranda Australia Ltd. continued development drilling at the Koongarra deposit and was participating in other exploration ventures. Pancontinental Mining Ltd., operator in a joint venture with Getty Oil Development Co. Ltd., was evaluating favorable anomalous areas. The Jabiluka 1 deposit was drilled out, and resources were reported at 3,850 tons U_3O_8. Jabiluka 2, 1,600 feet from Jabiluka 1, proved to be a substantial ore body, reported at 20,200 tons U_3O_8.

In South Australia the Petromin-Transoil-Exoil group (PTE) reported resources in the Beverly area, near Lake Frome, at 17,500 tons U_3O_8. Other companies were also active in this region.

In Western Australia, WMC completed development plans with auger, rotary, and diamond drilling in the Yeelirree area, where the mineralized area measured 28 by 2 miles along a buried stream channel. The ore is in horizontal beds, generally less than 25 feet below the surface. WMC announced reserves of 50,000 tons U_3O_8 in ore at 0.15% U_3O_8. including 26,000 tons U_3O_8 in high-grade ore at 0.36% U_3O_8.

Canadian uranium resources were higher than previously reported, particularly in the higher price categories. Estimated additional resources were nearly 70% higher than those reported for the NEA–IAEA Working Party in 1970.[65]

Exploration remained at a low ebb, owing to the continuing lack of market incentives and the Government attitude concerning restrictions on foreign ownership in the uranium industry. Minor exploration activities were underway in the Mont Laurier area of Quebec and in a few other areas. The main activity was in northern Sasketchewan, where Gulf Minerals conducted exploration in the Rabbit Lake area and planned drilling projects at several prospects. Other companies were also active in this region.[66]

As a result of continuing exploration and development drilling in Niger, the resource position at $10 per pound U_3O_8 improved substantially, particularly for resources moving into the more firmly established category. Reasonably assured resources at $10 per pound U_3O_8 reached 52,000 tons U_3O_8 and were expected to expand further. In addition to the producing Arlit mine and mill, the Government of Niger, the French CEA, and Japanese interests were engaged in a feasibility study of the Akouta deposit, where a substantial reserve has been established. The Niger Government, CEA, and Urangesellschaft m.b.H. of West Germany planned an exploration project at the Djado concession.

For the Republic of South Africa, NEA-ENEA reports of 263,000 tons U_3O_8 in resources at $10 per pound U_3O_8, a substantial increase over previous estimates, include resources in the Rossing deposit in the Territory of South-West Africa. Actual resources within the Republic, mainly in byproduct uranium from gold mines, have not changed significantly.

Exploration was underway by a number of major companies in the Beaufort West-Fraserburg area, 250 miles east-northeast of Cape Town. Extensive areas of low-grade mineralization (0.05% U_3O_8) in sandstones and conglomeratic sandstones were considered of significant potential. The Government planned an airborne survey of a 1,200-square-mile area.

TECHNOLOGY

A method for uranium identification by neutron activation and X-ray spectrometry was reportedly developed in Israel.[67] The neutron activation of a liquid or solid sample takes place in a reactor, and the X-ray spectrometry determines uranium and thorium content in geological materials with accuracy within a few percent. The

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[65] Williams, R. M., and H. W. Little. Canadian Uranium Resource and Production Capability. Min. Bull. MR 140, Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa, Canada, 1973, 27 pp.

[66] Pages 111–114 of work cited in footnote 47.

[67] Mantel, M., and S. Amiel. Simultaneous Determination of Uranium and Thorium by Instrumental Neutron Activation and High Resolution X-Ray Spectrometry. Anal. Chem., v. 45, No. 14, December 1973, pp. 2393–2399.

method was considered rapid, using the short half-lives of certain radioisotopes.

The distribution and zoning of uranium and other radioelements in porphyry copper deposits was analyzed by gamma-ray spectrometry. Uranium was found to be concentrated centrally or peripherally in different rock compositions of the porphyry copper deposits in Arizona and New Mexico.[68]

The presence of dissolved helium in ground water was used as a tool in exploration for uranium ore deposits. Helium flux was considered to be higher near these deposits; measurements near two known uranium deposits in Canada indicated a helium content up to 600 times normal for its solubility equilibrium with the atmosphere.[69] Another exploration technique involved the horizontal tracking of gaseous decay products, such as radon, in the atmosphere to source areas by correlation with wind conditions, after the radon had diffused to the surface from uranium deposits and became windborne.[70] In another technique using radon emanometric data, soil gas was extracted from drill holes, 2 to 4 inches in diameter and 3 feet deep, by a probe connected to a hand pump, and the radon content was measured in an alpha counting chamber.[71] This procedure was employed for roll front sandstone-type uranium deposits but may be used in exploration for other ores where uranium is an accessory mineral.

The AEC's Oak Ridge National Laboratory reported a new procedure for solvent extraction of uranium at WPPA operations. Tetravalent uranium is extracted with dioctyl phenyl phosphoric acid and is then stripped with product acid (54% H_3PO_4). The uranium is then oxidized to the hexavalent state with sodium chlorate. In a second stage, uranium is extracted with ethyl hexyl phosphoric acid (EHPA) and trioctyl phosphoric oxide (TOPO) and stripped with sodium carbonate. In an adaptation during WPPA processing, using HCL on the phosphate rock, the pregnant liquor is contacted with a mixture of dioctyl phosphate and dodecane, and the extractant is treated with water, the uranium entering the aqueous phase, which is separated for conventional processing.[72]

Research continued on health and safety in uranium mines. Filters, with vermiculite as the filtering material, were used in dust and radon control. Total dust, respiratory dust, and radon daughter collection efficiencies were analyzed statistically. The velocity of ventilation rather than the filter thickness affected radon daughter filtration. Other filter materials were more efficient, but vermiculite was lower in cost, easy to handle, resistant to moisture, and could withstand a large pressure drop.[73]

A method was proposed for removal of radon and other hazardous gases from a uranium ore body by drilling out the deposit, pumping ground water to establish permeability to gas within the formation, and then pumping the radon gas through the drill holes as the deposit is mined.[74]

A new thermoluminescent dosimeter (TLD) was considered superior to the photographic film-type badge worn by underground miners for recording radiation exposure. The TLD crystal, composed of lithium or calcium fluoride, calcium sulfate, or lithium borate, absorbs X-ray or gamma-ray energy, causing the capture of electrons by certain crystal impurities, which impart the thermoluminescent properties to the crystal. The TLD is re-usable, more accurate, more sensitive to small radiation dosages, and less affected by temperature and humidity than the film-type badge.[75]

Uranium was recovered from Elliot Lake ores, Ontario, Canada, by vapor-phase

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[68] Davis, J. D., and J. M. Guilbert. Distribution of the Radioelements Potassium, Uranium, and Thorium in Selected Porphyry Copper Deposits. Econ. Geol., v. 68, No. 2, March/April 1973, pp. 145–150.

[69] Clarke, W. B., and G. Kugler. Dissolved Helium in Ground Water: A Possible Method for Uranium and Thorium Prospecting. Econ. Geol., v. 68, No. 2, March/April 1973, pp. 243–251.

[70] Milly, G. H. (assigned to Geomet Mining and Exploration Co.). Method of Prospecting for Uranium Ore, Thorium Ore, and Other Radioactive Ores. Can. Pat. 927,526, May 29, 1973.

[71] Caneer, W. T., and N. M. Saum. Radon Emanometry in Uranium Exploration. Colo. School Mines Res. Inst., Golden, Colo., 1974, 18 pp.

[72] Ketzin, Z., Y. Volkman, and D. Yakir (assigned to Israel Atomic Energy Commission). Recovery of Uranium Values From Aqueous Liquors Formed During WPPA Processing. British Pat. 1,328,673, Aug. 30, 1973.

[73] Washington, R. A., W. Chi, and R. Regan. The Use of Vermiculite to Control Dust and Radon Daughters in Underground Uranium Mine Air. Can. Min. and Met. Bull., v. 66, No. 731, March 1973, pp. 152–160.

[74] Blackwell, R. J., A. R. Hagedorn, and G. D. Ortloff (assigned to Esso Product Research Co.). Method of Withdrawing Radon or Other Hazardous Gases From an Underground Uranium Mine. U.S. Pat. 3,743,355, July 3, 1973.

[75] Chemical Week. Hot on the Trail of Radioactivity. V. 112, No. 26, June 27, 1973, p. 35.

chlorination.[76] Processing costs were considered comparable with those for conventional sulfuric acid leaching. With minus-12 mesh ore at 1,000° C, 340 pounds of chlorine were used per ton of ore, with 95% uranium recovery.

A strong acid leach of uranium afforded advantages over conventional dilute acid leaching for refractory ores. Costs were reduced because less ore grinding was necessary, less acid was consumed, and an agitated slurry leach was not required.[77]

In other ore-processing research, the leaching sulfuric acid was passed upward through the ore bed in a vat. The pregnant solution was removed from above for conventional processing, and the leached ore removed from the bottom of the vat. This procedure required less reagent use and minimized carryover of ore fines in the pregnant solution.[78]

Bureau of Mines research continued on extraction and elution of uranium from low grade ores and copper leach solutions. Solution flow in a compartmented continuous current ion-exchange column was regulated by an automatic control system. A test based on a solution upflow principle provided better uranium sorption efficiency from low-grade ores. A series of vertical sections in the column, separated by zones of reduced diameter, localized and increased the flow velocity and improved mixing in the higher sections. Uranium recovery from a bulk sample of Chattanooga shale, containing 0.006% U_3O_8, was more successful when agitation leaching followed an oxidation roast.

In a uranium heap-leaching operation, the leach solution was applied at the top of the heap for leaching to a desired depth.[79] The leached zone was then treated with water for several days or weeks, and the material slurried and moved to a settling basin, where the pregnant solution was recovered for processing. The same procedure may be followed on successive layers of the ore heap.

Uranium may also be recoverable from leach solutions, metallurgical processing solutions, or sea water by adsorption with titanated polyvinyl alcohol and desorption with an aqueous solution of sodium carbonate or ammonium carbonate.[80] Another process for recovery of uranium from sea water involved a belt with a layer of activated exfoliated vermiculite, which was moved through a solution, the vermiculite laminae absorbing uranium ions. The belt then moves through an elution station, where the ions are removed with a suitable reagent.[81]

A new method of gaseous diffusion uranium enrichment, called the shuttle method, was developed in Italy. In ordinary diffusion enrichment, the UF_6 goes through 1,700 to 2,000 diffusion stages. In the new procedure, the in-process material is subjected to repeated cycling through 100 to 200 stages. This required an elaborate system of in-process storage but lower capital investment in plant use and equipment.

Several gas-centrifuge enrichment models evolved from the AEC's Centrifuge Development Program. Four centrifuge prototypes were undergoing performance and reliability testing at Oak Ridge National Laboratory, Oak Ridge, Tenn. The aim was to develop manufacturing technology for component assembly and equipment fabrication. At the AEC laboratories at Livermore, Calif., and Los Alamos, N. Mex., enrichment by laser separation was under investigation. In theory, the isotopes (U_{235} and U_{238}) absorb light at slightly different energy levels. The separation process has proved successful in the laboratory, and commercial application was under study.[82]

Industrial applications of the high process heat of the gas-cooled reactor were under investigation in the United States and abroad. Gulf General Atomic Co. attempted the production of hydrogen by splitting H and O in ordinary water by a multistep thermochemical cycle using high-temperature, gas-cooled reactor (HTGR) heat in the range of 1,500° to 1,800° F.[83] Reactor

[76] Lapage, R, and J. W. Marriage. Extraction of Uranium from Elliot Lake Ore by Vapor-Phase Chlorination. J. Inst. Min. and Met., v. 182, No. 799, June 1973, pp. C101–C102.

[77] World Mining. Strong Acid Leaching For Uranium Ore. V. 26, No. 12, November 1973, p. 56.

[78] Mitterer, A. V. (assigned to Continental Oil Co.). Continuous Vat Leaching of Uranium Ore Under Quiescent Conditions. U.S. Pat. 3,777,003, Dec. 4, 1973.

[79] Lankenau, A. S., and J. L. Lake (assigned to Hazen Research, Inc.). Heap Leaching of Uranium Ore and/or Vanadium Ore. U.S. Pat. 3,777,004, Dec. 4, 1973.

[80] Yano, M., I. Yamamoto, and N. Yasuhira (assigned to Kuraray Co. Ltd.). Recovery of Uranium Values From Ore Leach Solutions, Metallurgical Process Solutions, or Sea Water. U.S. Pat. 3,778,498, Dec. 11, 1973.

[81] Gerber, A. M. Extraction of Single or Multiple Ions of Uranium and Other Metals From Sea Water or Brine on a Continuous Basis. U.S. Pat. 3,763,049, Oct. 2, 1973.

[82] Chemical Week. Laser Separation. V. 114, No. 3, Jan. 16, 1974, p. 29.

[83] American Nuclear Society. Production of Hydrogen Aim of GGA Program. Nuclear News, v. 16, No. 15, December 1973, pp. 79–80.

process heat also was considered for coal gasification, iron reduction, and as a coke substitute in the blast furnace.[84] Prototype nuclear steel plants, involving the gas-cooled reactor and a hot-gas direct reduction process, were under development in the United Kingdom, Japan and West Germany.[85] In Japan, a 6-year research program was underway on HTGR-generated nuclear heat utilization, which would reduce pollution and coking coal requirements and would save up to 12% in energy consumption.

AEC-sponsored research included studies on LMFBR fuels, materials, physics, components, and systems development.[86] Breeder fuels were tested for performance at rated power and operating conditions and for safety in abnormal situations. The objective was the development of high performance U–Pu carbide, nitride, and metal fuels with higher thermal efficiencies, higher fuel densities necessary for better breeding ratios, and reduced fuel fabrication costs and doubling time. The Fast Flux Test Facility at Hanford, Wash., which was re-scheduled for completion in 1977, will provide experience in LMFBR design, construction, operation, and maintenance and in fast flux irradiation of LMFBR fuels and materials.

Deformation studies on stoichiometric UO_2 crystals in fuels indicated that the presence of oxygen clusters in the fuel lowers yield stress and promotes cross-slip deformation.[87] Creep rates, studied at 1,300° C to 1,500° C and at 2,000 to 6,000 pounds per square inch, were found to be higher in mixed U–Pu carbide fuels than in U carbide fuels tested under similar conditions.[88] Grain size and porosity were factors in creep mechanism by grain-boundary sliding. Hot-hardness measurements indicated deformation by dislocation-impurity interactions. In fuels enriched to 1.82% U_{235}, tested in a reactor, the strain rate was proportional to the fission rate in a constant structural state, and radiation-induced creep was athermal at temperatures up to 500° C but may become temperature-dependent at higher temperatures.[89] Crack healing during grain growth was probably controlled by grain-boundary diffusion, if stress were small or compressive and diffusion not affected by fissioning.[90] This healing was of primary concern during initial reactor startup, when cracks may occur in oxide fuel pellets.

Nondestructive testing of LWR and FBR fuel materials by eddy current, penetrant, and ultrasonic methods was followed by radiographic fuel rod inspection and complementary techniques including gamma monitoring, fluoroscopy, and leak tests. The radioisotope Cf_{252} was used in neutron activitation analysis of pellet density, pellet enrichment, and fuel geometry.[91]

A new system of rapid refueling, on a semi-annual rather than annual basis, would permit savings during the refueling operation, due to a lower initial enrichment level needed and reduced downtime. For optimum performance, the fuel enrichment level tended to decrease as the number of refuelings increased.[92]

A newly developed cask for transporting spent fuel assemblies was licensed by the AEC in January. It consists of a lead gamma shield between two cylindrical steel shells, a compartmented neutron shield tank containing a borated antifreeze solution that serves as a neutron-shield, and multidirectional lightweight impact limiters. The vessel weighs 25 tons and will carry two BWR and one PWR fuel assemblies. It was designed for zero release of coolant solution in any hypothetical accident.[93] Another cask in service, the first accommodating the new, longer fuel assemblages, can carry 7 PWR or 18 BWR spent fuels by rail. It is cooled by natural convection and has an auxiliary forced-air circulation system.

In spent-fuels reprocessing, an electro-

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[84] American Nuclear Society. HTR: Process Heat Source by 1985. Nuclear News, v. 16, No. 10, August 1973, p. 58.

[85] American Institute of Mining, Metallurgical and Petroleum Engineers. Nuclear Steelworks by 1980. J. Metals, v. 25, No. 10, October 1973, p. 15.

[86] Pages 27–34 of work cited in footnote 2.

[87] Yost, C. S., and C. J. McHargue. Model for Deformation of Hyperstoichiometric UO_2. J. Am. Ceram. Soc., v. 56, No. 3, March 1973, pp. 161–164.

[88] Tokar, M. Compressive Creep and Hot Hardness of U–Pu Carbides. J. Am. Ceram. Soc., v. 56, No. 4, April 1973, pp. 173–177.

[89] Solomon, A. A. Radiation-Induced Creep of UO_2. J. Am. Ceram. Soc., v. 56, No. 3, March 1973, pp. 164–171.

[90] Roberts, J. T. A., and B. J. Wrona. Crack Healing in UO_2. J. Am. Ceram. Soc., v. 56, No. 6, June 1973, pp. 297–299.

[91] American Nuclear Society. Radiography and NDT in the Nuclear Industry. Nuclear News, v. 16, No. 11, September 1973, pp. 98–100.

[92] American Nuclear Society. New System Claimed to Save $20–65 per Kw. Nuclear News, v. 16, No. 7, May 1973, p. 43.

[93] American Nuclear Society. Fuel Cask Wins AEC Nod. Nuclear News, v. 16, No. 3, March 1973, p. 54.

lytic dissolver at the AEC's Chemical Processing Plant, National Reactor Testing Station, Idaho, enables faster, more economical processing of stainless-steel-clad fuels. An electric charge is applied to the metal cladding, which is immersed in nitric acid, causing the stainless steel, otherwise inert, to dissolve.

AEC capacity for high-level radioactive waste solidification was expected to be doubled with the 242–S Facility, which went into operation at Hanford, Wash., in November.[94] Waste solutions, steam-heated to 140° F to 165° F. are pumped to an evaporator-crystallizer facility, where the waste is boiled and the vapor collected and condensed at a rate of 40 gallons per minute. The remaining waste slurry is then pumped back to storage for settling of solids.

Two new processes for high-level waste treatment and solidification were also developed at Hanford. A pilot plant will provide engineering data on waste treatment by hot, concentrated sulfuric and nitric acid digestion. It was reported that each 100 kilograms of fuel produced 28 cubic feet of contaminated materials. In solidification, radioactive salt cake from underground storage tanks was converted to a hard insoluble rock-like material with basalt at 1,200° C and with iron oxide, silicon, and sand at 2,000° C.[95] The Japanese Atomic Energy Research Institute announced a method for high-level waste solidification by conversion to a glass, using sodium carbonate and other chemicals added to a zeolite.

Slightly radioactive oil generated at enrichment plants, formerly buried in drums, was fed to natural micro-organisms in soil at an Oak Ridge National Laboratory test area. The oil was consumed and dissipated as CO_2, and chemical contaminants were trapped in the soil. The process appeared effective, with no adverse environmental effects.[96]

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[94] Page 118 of work cited in footnote 2.

[95] Atomic Industrial Forum. Two New Hanford Processes Show Rich Promise in Waste Management. Nuclear Ind., v. 20, No. 10, October 1973, p. 29.

[96] Chemical Week. New Approach to Disposal of Slightly Radioactive Oil. V. 113, No. 15, Oct. 10, 1973, p. 22.

Vanadium

By Harold A. Taylor, Jr.[1]

Domestic demand for vanadium reached an alltime high in 1973, slightly above the previous high of 1969. Overseas demand was also quite strong. Domestic production of vanadium pentoxide was somewhat lower than that in 1972, mostly the result of the Uravan-Rifle complex being partially shut down until May while the vanadium circuit was rebuilt. Exports of ferrovanadium were more than five times those of the previous year. Exports of vanadium ores and oxides also rose significantly above those of the previous year. The Government sold all of its ferrovanadium in the first half of the year.

Legislation and Government Programs.—On April 12, the Office of Preparedness decreased the vanadium pentoxide stock pile objective from 540 short tons of contained vanadium to zero, thereby eliminating the last remaining vanadium objective. Congressional authorization must be obtained before the remaining pentoxide can be sold.

The General Services Administration sold the 1,200 short tons (vanadium content) of ferrovanadium that remained in Government stockpiles. Of the 1,000 short tons sold to producers of ferrovanadium, 69% went to Shieldalloy Corp., 26% to Susquehanna-Western, Inc., and the balance to Gulf Chemical and Metallurgical Corp. Various metal traders bought the remaining 200 tons. No export restrictions were placed on this material.

As of December 31, 1973, the Government had an inventory of 1,231 short tons of vanadium, all in the national stockpile. Of this total, which includes material sold but not delivered, 399 tons was held as ferrovanadium and 832 tons was held as vanadium pentoxide.

[1] Physical scientist, Division of Ferrous Metals—Mineral Supply.

Table 1.—Salient vanadium statistics

(Short tons of contained vanadium)

	1969	1970	1971	1972	1973
United States:					
Production:					
Ore and concentrate:					
Recoverable vanadium [1]	5,577	5,319	5,252	4,887	4,377
Value thousands	$26,334	$34,923	$37,690	$30,867	$26,611
Vanadium pentoxide recovered	5,906	5,594	5,293	5,248	4,864
Consumption	6,154	5,134	4,802	5,227	6,393
Exports:					
Ferrovanadium and other vanadium alloying materials (gross weight)	644	2,155	676	269	1,416
Vanadium ores, concentrates, oxides, and vanadates	258	973	260	176	232
Imports (General):					
Ferrovanadium (gross weight)	449	21	89	578	303
Ores, slags and residues	2,250	2,000	2,350	1,400	2,600
World production	18,581	20,171	r 18,511	20,679	21,285

r Revised.
[1] Recoverable vanadium contained in uranium and vanadium ores and concentrates received at mills, plus vanadium recovered from ferrophosphorus derived from domestic phosphate rock.

DOMESTIC PRODUCTION

The principal domestic source of vanadium in 1973 was the vanadium ore of Arkansas. The amount of vanadium recovered from Colorado Plateau uranium-vanadium ores declined, and the amount of vanadium recovered from ferrophosphorus did not change significantly. Some of the mills also processed vanadium-bearing oil residues, spent catalysts, vanadium-bearing residues from titanium dioxide production, and foreign vanadium-bearing slags.

The recovered vanadium pentoxide figures in tables 1 and 3 do not include vanadium recovered from imported vanadium-bearing slag. None of the figures include the vanadium recovered in any operation that produced ferrovanadium directly from slag or residue.

The Hot Springs, Ark., plant of Union Carbide Corp. produced all the vanadium recovered from Arkansas vanadium ore in 1973. The Uravan-Rifle mill complex of Union Carbide Corp. produced almost all the vanadium recovered from uranium-vanadium ores that year. The Soda Springs, Idaho, plant of Kerr-McGee Corp. and the Hot Springs, Ark., plant of Union Carbide Corp. produced all the vanadium recovered from byproduct ferrophosphorus. Other producers of vanadium from domestic ores and/or residues in 1973 included the Edgemont, S. Dak., mill of Susquehanna-Western, Inc.; the Wilmington, Del., plant of The Pyrites Co., Inc.; and the Moab, Utah, mill of Atlas Corp. Producing states include Arkansas 1971–73, Colorado 1971–73, Idaho 1971–73, New Mexico 1971–73, South Dakota 1972, and Utah 1971–73.

On October 1, the Atomic Energy Commission (AEC) began inviting bids for mining leases on 43 tracts of AEC-controlled land totaling about 25,000 acres. The land, mostly in the Uravan Mineral Belt of western Colorado, contains an estimated $45 to $50 million worth of uranium reserves and has good potential for further ore discovery. Included in the areas being offered were some lands mined under Government lease prior to 1962, when the leases were allowed to expire because of reduced procurement requirements for uranium. The leases, to be awarded on the basis of a competitive royalty bid, will have the royalty expressed as a percent of the value per dry ton of ore, this value to include both uranium and vanadium except for two tracts where the vanadium content of the ore is insignificant. AEC reserved 18 of the tracts for bidding by small business concerns and attached special terms to some of the other tracts. The opening of this new land to mining is expected to significantly prolong the life of the Colorado Plateau uranium-vanadium industry.

Earth Sciences Inc. awarded a $115,000 contract to the Ralph M. Parsons Co. for an economic feasibility study of a deposit of 15 to 25 million tons of material that is reported to average 0.76% vanadium. Earth Sciences controls the mineral rights to 3,000 acres of land in southeastern Idaho on which the deposit is located. Prior to awarding the contract, the company did some core drilling, some underground mine testing, and some hydrometallurgical testing on bulk samples mined underground.

The Pyrites Co., a subsidiary of Rio Tinto-Zinc Corp. Ltd., discontinued production at its vanadium operation at Wilmington, Del.

Table 2.—Mine production and recoverable vanadium of domestic origin produced in the United States

(Short tons of contained vanadium)

Year	Mine production [1]	Recoverable vanadium [2]
1969	5,737	5,577
1970	5,793	5,319
1971	5,547	5,252
1972	4,699	4,887
1973	4,117	4,377

[1] Measured by receipts of uranium and vanadium ores and concentrates at mills, vanadium content.

[2] Recoverable vanadium contained in uranium and vanadium ores and concentrates received at mills, plus vanadium recovered from ferrophosphorus derived from domestic phosphate rock.

Table 3.—Production of vanadium pentoxide in the United States [1]

(Short tons)

Year	Gross weight	V_2O_5 content
1969	12,120	10,542
1970	11,035	9,986
1971	10,492	9,448
1972	10,410	9,367
1973	8,226	8,683

[1] Includes vanadium pentoxide and metavanadate produced directly from all domestic sources, plus small byproduct quantities from imported chromium ores in 1971 and the preceding years.

CONSUMPTION AND USES

Domestic consumption of vanadium as reported for all types of material in table 4, or all end-use categories in table 5, rose about 22% in 1973. Increases occurred in all major end-use categories; the increase in consumption in the tool steel and nonferrous alloy categories was especially noteworthy. Consumption was at a fairly uniform high level from month to month during the year.

Westinghouse Electric Corp. received a $90 million contract for the nuclear reactor portion of the liquid-metal-cooled, fast-breeder reactor demonstration power-plant in Tennessee. Plans call for the plant to be operated by the Tennessee Valley Authority and to be on line by 1980. If vanadium metal is used as a structural material in this and other such reactors, a sizeable new market would be opened for vanadium.

The Vanadium International Technical Organization was launched during the year by most of the major producers of vanadium raw materials and ferrovanadium. It will sponsor research intended to lead to greater use of vanadium; its immediate objective is to develop vanadium-bearing high-yield steels for application under extreme conditions.

Table 4.—Consumption and consumer stocks of vanadium materials in the United States

(Short tons of contained vanadium)

Type of material	1972 Consumption	1972 Ending stocks	1973 Consumption	1973 Ending stocks
Ferrovanadium [1]	4,493	623	5,600	1,135
Oxide	189	56	199	49
Ammonium metavanadate	47	8	45	9
Other [2]	498	101	549	98
Total	5,227	788	6,393	1,291

[1] Includes other vanadium-iron-carbon alloys.
[2] Consists principally of vanadium-aluminum alloy, plus relatively small quantities of other vanadium alloys and vanadium metal.

Table 5.—Consumption of vanadium in the United States, by end use

(Short tons of contained vanadium)

End use	1973
Steel:	
Carbon	687
Stainless and heat resisting	26
Full alloy	1,544
High-strength, low-alloy	2,252
Electric	W
Tool	997
Cast irons	56
Superalloys	38
Alloys (excluding steels and superalloys):	
Cutting and wear resistant materials	W
Welding and alloy hard-facing rods and materials	11
Nonferrous alloys	527
Other alloys [1]	16
Chemical and ceramic uses:	
Catalysts	163
Other [2]	W
Miscellaneous and unspecified	76
Total	6,393

W Withheld to avoid disclosing individual company confidential data, included in "Miscellaneous and unspecified."
[1] Includes magnetic alloys.
[2] Includes pigments.

STOCKS

In addition to the consumers' stocks shown in table 4, producers' stocks of vanadium as fused oxide, precipitated oxide, metavanadate, metal, alloys, and chemicals totaled 2,815 short tons of contained vanadium at yearend 1973, compared with 3,540 tons (revised) at yearend 1972.

PRICES

Prices for vanadium pentoxide were unchanged in 1973. The price quoted by Metals Week for dealer export merchant technical-grade vanadium pentoxide continued to be $1.50 per pound of contained V_2O_5 for the entire year. The price for domestic 98% fused vanadium pentoxide (metallurgical markets) also remained $1.50 per pound of contained V_2O_5 in 1973. The price for technical-grade, air-dried vanadium pentoxide stayed at $2.21 per pound of contained V_2O_5, f.o.b. plant, for the entire year.

Kerr-McGee tried to increase its 98% fused vanadium pentoxide price on July 1 to $1.65 per pound of contained V_2O_5, a 10% increase from its previous price. The increase followed price increases by Highveld Steel and Vanadium Corp. of South Africa and reflected an improved market for vanadium. Although the Government's price freeze prevented the implementation of this price increase, it was indicative of the market at the time.

No changes occurred in the U.S. ferrovanadium prices either. The price for U.S. standard grade ferrovanadium remained at $4.19 per pound of contained vanadium f.o.b. shipping point for the entire year. The price for Carvan stayed at $3.66 per pound of contained vanadium in 1973. The price for Ferovan continued at $3.68 per pound of contained vanadium during the year.

Metal Bulletin's United Kingdom price for ferrovanadium containing 50% to 60% V rose over 12% from the beginning of the year to early April, after which it leveled off for the rest of the year.

FOREIGN TRADE

Exports of ferrovanadium were somewhat larger in the latter part of the year, with an especially large shipment leaving in July. Exports of vanadium ores and oxides were concentrated in the middle part of the year. The declared value for exports of ores, concentrates and technical-grade oxides averaged $1.40 per pound of contained vanadium pentoxide in 1973, compared with $1.21 in 1972. The declared value for exports of ferrovanadium averaged $3.08 per pound of alloy, compared with $2.34 in 1972.

Imports classified as vanadium ore and concentrate totaled 31,920 pounds of contained vanadium in 1973. Imports classified as vanadium carbide totaled 43,190 pounds (gross weight); almost all of it was from the Republic of South Africa. Imports classified as unwrought, waste and scrap vanadium metal, vanadium compounds, and organic vanadium salts totaled 80,203 pounds (gross weight). Imports of vanadium-bearing materials such as ashes and slags, which are classified as metal-bearing residues, were estimated to be about 5.2 million pounds of contained vanadium in 1973, compared with 2.8 million pounds in 1972. In both years, most of these materials originated in the Republic of South Africa and Chile.

Table 6.—U.S. exports of vanadium, by country

(Thousand pounds and thousand dollars)

Destination	Ferrovanadium and other vanadium alloying materials containing over 6% vanadium (gross weight)				Vanadium ore, concentrates, pentoxide, vanadic acid, vanadium oxide, and vanadates (except chemically pure grade) (vanadium content)			
	1972		1973		1972		1973	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Algeria	--	--	66	198	--	--	--	--
Austria	--	--	--	--	101	216	124	310
Belgium-Luxembourg	74	129	--	--	--	--	--	--
Brazil	--	--	33	97	--	--	--	--
Canada	221	596	614	1,844	--	--	26	57
Colombia	2	5	--	--	--	--	--	--
Dominican Republic	--	--	(1)	1	--	--	--	--
France	--	--	--	--	(1)	1	95	183
Germany, West	--	--	349	1,080	117	247	40	115
Hong Kong	--	--	5	18	--	--	--	--
India	18	34	--	--	--	--	--	--
Jamaica	--	--	--	--	--	--	(1)	1
Japan	29	57	78	233	--	--	39	108
Mexico	95	231	13	39	31	73	42	110
Netherlands	--	--	433	1,453	--	--	37	99
Poland	--	--	407	1,244	--	--	--	--
Spain	17	42	401	1,207	--	--	--	--
Sweden	--	--	314	989	--	--	--	--
Switzerland	81	162	96	275	102	219	--	--
United Kingdom	--	--	23	56	--	--	61	174
Total	537	1,256	2,832	8,734	351	756	464	1,157

[1] Less than ½ unit.

Table 7.—U.S. imports of ferrovanadium, by country

(Thousand pounds and thousand dollars)

Country	1972			1973		
	Gross weight	Vanadium content	Value	Gross weight	Vanadium content	Value
General imports:						
Australia	--	--	--	66	38	116
Austria	255	207	648	167	134	375
Belgium-Luxembourg	44	36	113	--	--	--
Canada	14	11	38	93	73	256
Germany, West	549	411	1,194	231	180	575
Norway	140	67	197	48	21	63
Sweden	68	55	164	--	--	--
Switzerland	85	50	151	--	--	--
Total	1,155	837	2,505	605	446	1,385
Imports for consumption:						
Australia	--	--	--	66	38	116
Austria	255	207	648	108	99	254
Belgium-Luxembourg	44	36	113	--	--	--
Canada	14	11	38	93	73	256
Germany, West	386	282	817	154	120	364
Norway	56	26	76	133	63	184
Sweden	68	55	164	--	--	--
Switzerland	85	50	151	--	--	--
Total	908	667	2,007	554	393	1,174

WORLD REVIEW

In addition to the nations shown in table 8, several others produced relatively minor amounts of vanadium, usually from secondary, waste, or byproduct sources. Canada, Japan, and West Germany produced vanadium from several such sources. The world market for vanadium was quite strong in 1973, although a little weakening appeared towards the end of the year.

Australia.—The Ralph M. Parsons Co. completed an initial feasibility study for Ferrovanadium Corp. N.L. on the latter's ore deposit at Barrambie, Western Australia. The study recommended a concentrator at the mine site, a pipeline to move the concentrate 300 miles to Geraldton, and an electrometallurgical and chemical plant at Geraldton. Such an operation would cost $100 million and be able to produce over 3,000 short tons of vanadium as pentoxide, plus other products.

Under terms of an agreement with Ferrovanadium Corp. N.L., Pacminex Pty. Ltd., a subsidiary of CSR, Ltd., made a preliminary examination of the Barrambie project, after which it had the right to acquire 51% of the project. After examination, Pacminex withdrew from the project, explaining that the potential rewards to the company would not justify the expense and risk that would be incurred.

Canada.—The Mines Branch, Department of Energy, Mines and Resources, developed a pyrometallurgical process to recover vanadium and nickel from the fly ash that results from processing Athabasca tar sands. Recovery of these metals may be economically feasible when enough tar sand is being processed to recover over 200,000 barrels of synthetic crude per day; about 60,000 barrels per day is now being recovered.

Finland.—According to Finnish trade statistics, Finland exported 2,690 short tons of vanadium compounds[2] in 1972, of which 761 tons went to Sweden, 712 tons to West Germany, 482 tons to France, 331 tons to the U.S.S.R., and the balance to other European nations and Canada.

Germany, West.—According to official trade statistics, West Germany imported 33,664 short tons (gross weight) of vanadium-containing ashes, residues, and slag in 1973; 5,784 tons came from Hungary, 1,849 tons from France, 655 tons from Belgium-Luxembourg, 600 tons from Mozambique, 592 tons from the U.S.S.R., 255 tons from the Netherlands, 451 tons from other European, North American, and Israeli sources, and the balance from unspecified sources.

India.—Ferrovanadium production was 79 short tons in 1973, compared with 66 tons in 1972 and 52 tons in 1971. India exported 18,715 short tons (gross weight) of low-grade vanadium ore worth $950,900 in 1973, compared with 811 tons worth $61,470 in 1972 and 441 tons worth $24,930 in 1971.

The Geological Survey of India and the Orissa State Directorate of Mines are making a detailed investigation of the vanadiferous magnetite deposits of Orissa and Bihar, including field work. So far, they have proved enough ore to sustain Orissa State's proposed ferrovanadium plant for 10 years.[3] The Government of India has decided to include construction of this plant in its Fifth Plan (1974–79).

Dr. M. S. Patel of Bombay was attempting to complete arrangements for building a plant to recover 1,100 tons of vanadium per year as pentoxide from a titanomagnetite ore deposit in Bihar. Ore samples were being tested by a prospective collaborator in the United States.

South Africa, Republic of.—Production of vanadium-bearing slag by Highveld Steel and Vanadium Corp., Ltd., totaled 37,560 short tons (gross weight) in the fiscal year ending June 30, 1973, compared with 31,072 short tons in the previous fiscal year. This large increase reflects the solution of some long-standing problems in the iron plant and the resulting operation of the iron plant at its rated capacity. As a result of improving demand for vanadium pentoxide, the company operated its Vantra Division pentoxide plant at full capacity from the end of 1972 until October 1973, after which output was reduced in response to the reappearance of a weaker market. As a result of record production and sales, the company was able to declare the first dividend on its common stock.

Highveld Steel and Vanadium Corp., Ltd., announced plans to spend R14 million to

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[2] Although the title of the export class is "vanadium compounds," the material is almost all vanadium pentoxide.

[3] Nanda, A. K. Our Resources of Vanadium Ore. J. of Mines, Metals, and Fuels (Calcutta), v. 21, No. 12, December 1973, pp. 373–376, 387.

expand vanadium-bearing slag and steel output by 25% at its Witbank plant. This would involve adding a sixth kiln, a fifth submerged arc iron melting furnace, a fourth continuous-casting machine, major modifications in the steel plant, and some expenditures at the Mapochs mine. The additional slag would be exported, as would most of the steel semimanufactures until such time as installation of a rolling mill becomes feasible.

Transvaal Alloys, Ltd., is mining a vanadium ore body near Uitvlugt, Transvaal, under a lease from Bushveld Development (Pty.) Ltd., and is expecting to remove 1.2 million tons of ore by the time the lease expires in February 1974. The company's vanadium pentoxide plant complex near Stoffberg is expected to be onstream in early 1974.

U.S.S.R.—The Kachkanar mining and beneficiation complex is reported to have reached its rated capacity of 36 million short tons of crude titanomagnetite ore per year, from which a concentrate containing about 18,000 tons of vanadium is produced. Rising demand for ferrotitanium has resulted in plans for expanding the capacity to 44 million tons of ore per year by the end of 1975.

Venezuela.—The Venezuelan Ministry of Mines and Hydrocarbons contracted with Gas Development Corp. for an evaluation of the possible development of the Orinoco heavy oils, and their associated vanadium and nickel values. Results of the study indicate that there are good prospects for producing 1 million barrels of oil per day, at which level an estimated 9,500 tons of byproduct vanadium per year could also be recovered. Total heavy oil in place is about 700 billion barrels, recovery of 2% to 10% of which could reasonably be expected. Because the metals contained in the heavy oil contaminate the catalysts used in processing the heavy oil into the final petroleum products, the metals must be removed first. Two types of processes seem most likely to be used for metal removal, one involves concentration of the metals in the asphaltene fraction and subsequent removal and the other involves deposition of the metals on a cheap material (probably a catalyst).[4]

[4] Reyes, A., J. Huebler, and C. W. Matthews. Metal By-products From Processing Venezuelan Heavy Crudes. Pres. at the International Symposium on Vanadium and Other Metals in Petroleum, Maracaibo, Venezuela, Aug. 19–22, 1973, 11 pp.

Table 8.—Vanadium: World production from ores and concentrates, by country
(Short tons of contained vanadium)

Country	1971	1972	1973 [p]
Chile [e]	660	720	1,060
Finland (in vanadium pentoxide product)	1,222	1,312	1,388
France [e] [1]	100	100	90
Norway [e]	[r] 1,100	[r] 1,060	800
South Africa, Republic of:			
Content of pentoxide and vanadate products [e]	2,470	3,370	3,530
Content of vanadiferous slag product [e]	4,060	4,860	5,540
Total	6,530	8,230	9,070
South-West Africa, Territory of: (in lead-vanadate concentrate) [e]	730	[r] 650	800
U.S.S.R. (in slag exports)[2]	2,917	3,720	[e] 3,700
United States (recoverable vanadium)	5,252	4,887	4,377
Total	[r] 18,511	20,679	21,285

[e] Estimate. [p] Preliminary. [r] Revised.
[1] Byproduct derived from bauxite.
[2] Partial figure representing only that vanadium contained in exported slags; does not include vanadium produced for domestic consumption in any form or for export in any form except slag.

TECHNOLOGY

A considerable volume of research on vanadium was conducted in 1973, most of it dealing with vanadium metal and alloys which could possibly be used as fuel-cladding materials in fast-breeder reactors, with the recovery of vanadium from petroleum, and with the vanadium released into the atmosphere by petroleum combustion and soil erosion. The research dealing with recovery of vanadium from petroleum received comprehensive coverage at a symposium on vanadium in petroleum held in Venezuela.

The Bureau of Mines made high-purity

(over 99.8%) vanadium metal by magnesium reduction of vanadium dichloride, obtaining yields of over 98%.[5]

Vanadium-chromium and vanadium-molybdenum alloys were found to have a lower oxygen solubility than vanadium metal when specimens of the metal and its alloys were exposed to an oxygen-containing coolant-type liquid sodium such as proposed for the fast-breeder reactor.[6]

Extensive adoption of the Flexicoking process could result in the recovery of large quantities of vanadium from crude residua in oil refineries, as requirements for low-polluting desulfurized demetallized petroleum products increase. The process combines fluid coking with coke gasification and concentrates 99% of the contained metals into a small purge stream while converting the residua into gas and lighter demetallized liquid amenable to further processing. Some of the purge stream product may be too low grade to make recovery worthwhile; this is evidenced by the purge stream product containing under 6% vanadium even when a high-metal Venezuelan feedstock was used. A semicommercial Flexicoking unit is now being built in Texas for startup in early 1974, and three commercial units are now being designed—two for Japan and one for the United States.[7]

Some other methods for recovering vanadium from petroleum were mentioned at the International Symposium on Vanadium and Other Metals in Petroleum, held August 19–22 in Maracaibo, Venezuela. One method involved extracting the vanadium directly from the petroleum with an aqueous solution of a strong complexing agent. Another possibility would involve removing the asphaltene fraction, which contains almost all of the vanadium, from the crude petroleum by electrodeposition. Vanadium could be recovered from petroleum by being adsorbed on bauxite in either a batch or a flow reactor. Vanadium could be obtained also, along with a synthetic natural gas and benzene, from a Venezuelan-type residuum by hydrogenation in a high-velocity fluidized bed.

The origin of vanadium-containing airborne particulates was determined at various locations. The atmospheric vanadium sampled in Puerto Rico was probably from the soil; the atmospheric vanadium sampled in the San Francisco Bay area appeared to be both from the soil, in the case of the larger particles, and from the combustion of petroleum, in the case of the smaller particles.[8] In Japan, vanadium concentration in the atmosphere was closely correlated to the amount of fuel oil burned and to the concentration of sulfur dioxide in the atmosphere.[9]

A variety of processes for separating vanadium-bearing solutions, sodium hexavanadate, ferrovanadium, or vanadium metal from various raw materials were patented in 1973. A vanadium-bearing solution can be recovered from a silica-containing titaniferous magnetic ore, such as that found in Tahawus, N.Y., by roasting a mixture of ore, a sodium salt, and cryolite at a temperature under 1,350° C for 30 minutes to 2 hours, and then leaching the mixture.[10]

Sodium hexavanadate can be recovered from the post-distillation residue which results from fractionating titanium tetrachloride from titanium ore or slag. Steps include uniformly contacting the residue with superheated steam in the presence of air, carbon dioxide, and carbon monoxide, treating it with aqueous sodium hydroxide, roasting it, extracting it with water, and filtering it to obtain a precipitate of sodium hexavanadate.[11]

A ferrovanadium-like alloying additive can be produced from fuel ash residue by leaching the residue, treating the leach solution

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[5] Campbell, T. T., J. L. Schaller, and F. E. Block. Preparation of High-Purity Vanadium by Magnesium Reduction of Vanadium Dichloride. Met. Trans., v. 4, No. 1, January 1973, pp. 237–241.

[6] Klueh, R. L., and J. H. Devan. The Effect of Oxygen in Static Sodium on Vanadium and Vanadium Alloys: I. Unalloyed Vanadium, Vanadium-Chromium, and Vanadium-Molybdenum Alloys. J. Less-Common Metals, v. 30, No. 1, January 1973, pp. 9–24.

[7] Pagel, J. F., J. A. Rionda, and F. A. Fuentes. Vanadium Recovery in the Refinery via Flexicoking of Residua. Pres. at the International Symposium on Vanadium and Other Metals in Petroleum, Maracaibo, Venezuela, Aug. 19–22, 1973, 22 pp.

[8] Martens, C. S., J. J. Wesolowski, R. Kaifer, and W. John. Sources of Vanadium in Puerto Rican and San Francisco Bay Area Aerosols. Environmental Sci. and Technol., v. 7, No. 9, September 1973, pp. 817–820.

[9] Sugimae, A., and T. Hasagawa. Vanadium Concentrations in Atmosphere. Environmental Sci. and Technol., v. 7, No. 5, May 1973, pp. 444–448.

[10] Fox, J. S., and W. H. Dresher (assigned to Union Carbide Corp.). Recovery of Vanadium From Titaniferous Iron Ores. U.S. Pat. 3,733,193, May 15, 1973.

[11] Sato, M., T. Yano, K. Hara, Y. Nawa, and K. Maruyama (assigned to NGK Insulators, Ltd.). Process for Recovering Vanadium Oxide. U.S. Pat. 3,754,072, Aug. 21, 1973.

successively with finely divided carbon, ferric chloride, and ammonium chloride to precipitate a complex of vanadium and iron, and reducing the precipitate to get the additive.[12] Vanadium metal can be produced from vanadium ore or oxide by entraining the vanadium-bearing material in flowing methane or propane, introducing the flow axially into an electric arc heater and heating it sufficiently to get reduction to the metal, and letting the metal blow out of the exhaust port of the heating chamber.[13]

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[12] Vojkovic, M. (assigned to Continental Ore Corp.). Recovery of Refractory Metal Values. U.S. Pat. 3,758,665, Sept. 11, 1973.

[13] Frey, M. G., and G. A. Kemeny (assigned to Westinghouse Electric Corp.). Method of Direct Ore Reduction Using a Short Cap Arc Heater. U.S. Pat. 3,765,870, Oct. 16, 1973.

Vermiculite

By Frank B. Fulkerson [1]

In 1973 crude vermiculite production increased 8% to the record high of 365,000 short tons. The crude vermiculite, mined in Montana and South Carolina, was shipped to plants in 31 States for exfoliation. The quantity of exfoliated vermiculite sold and used by producers increased 19%. The exfoliated material was used mainly in the building industry for lightweight concrete aggregate, loose fill insulation, and other purposes.

DOMESTIC PRODUCTION

Crude Vermiculite.—Output increased from 337,000 short tons in 1972 to 365,000 short tons in 1973. The only producers of crude vermiculite were the Construction Products Division, W. R. Grace & Co., with mines near Libby, Mont., and Enoree, S.C., and Patterson Vermiculite Co., Lanford, S.C. W. R. Grace & Co. nearly completed construction on a new $7 million wet processing plant near Libby. The new plant will produce in excess of 1,000 tons per day of bulk vermiculite concentrate.

Exfoliated Vermiculite.—The tonnage of exfoliated vermiculite sold or used by producers increased from 247,000 in 1972 to 293,000 in 1973. Fifty-five plants in 31 States produced the lightweight product. The following five States supplied 41% of the national total: California, Florida, New Jersey, South Carolina, and Texas. W. R. Grace & Co., the leading producer of crude vermiculite, operated 27 exfoliating plants in 22 States. Patterson Vermiculite Co. consumed all its production of crude vermiculite at its Lanford, S.C., exfoliating plant. A quantity of crude vermiculite from the Republic of South Africa was exfoliated in the United States.

Table 1.—Salient vermiculite statistics

	1969	1970	1971	1972	1973
United States:					
Sold and used by producers:					
Crude ----thousand short tons--	310	285	301	337	365
Value ----thousand dollars--	$6,805	$6,501	$7,198	$8,092	$9,464
Average value per ton ----	$21.95	$22.81	$23.91	$24.01	$25.93
Exfoliated ----thousand short tons--	250	221	209	247	293
Value ----thousand dollars--	$19,916	$18,809	$20,885	$24,777	$31,186
Average value per ton ----	$79.66	$85.11	$99.93	$100.31	$106.44
World: Production, crude ----thousand short tons--	466	431	459	512	551

CONSUMPTION AND USES

By main categories, the use pattern for exfoliated vermiculite was as follows: Aggregates, 47%; insulation, 31%; agriculture, 17%; and miscellaneous, 5%. End uses in 1972 and 1973 are shown in thousand tons in the following tabulation:

[1] Industry economist, Division of Nonmetallic Minerals—Mineral Supply.

Use	1972	1973
Aggregates:		
Concrete	80	88
Plaster and cement [1]	24	49
Total	104	137
Insulation:		
Loose fill	74	82
Block	8	9
Packing	2	1
Total	84	92
Agriculture:		
Horticulture	40	40
Fertilizer carrier	11	9
Other	1	1
Total	52	50
Miscellaneous	7	14
Grand total	247	293

[1] Includes vermiculite aggregate for products mixed on site as well as premixes for acoustic and fireproofing purposes, etc.

PRICES

The Engineering and Mining Journal quoted nominal yearend prices for crude vermiculite as follows: Per short ton, f.o.b. mines, Montana and South Carolina, $25 to $38; and c.i.f. Atlantic ports, Republic of South Africa ore, $55 to $70.

The average mine value of domestic crude vermiculite, screened and cleaned, was $25.93 per short ton, compared with $24.01 in 1972. The average value, f.o.b. producing plant, of exfoliated vermiculite, was $106.44 per short ton, compared with $100.31 in 1972. These values exclude container cost where applicable.

FOREIGN TRADE

Crude vermiculite was imported duty free into the United States. The Republic of South Africa was the only important source of vermiculite imports. A quantity of crude vermiculite was exported from the United States to Canada; however, tonnage figures were not published.

WORLD REVIEW

Canada.—All crude vermiculite exfoliated in Canada was imported from the United States and the Republic of South Africa, with the Libby, Mont. mine of W.R. Grace & Co. supplying most of the tonnage. Five companies exfoliated vermiculite at nine locations in 1972. The plants were in Vancouver, British Columbia (two plants); Edmonton, Alberta; Regina, Saskatchewan; Winnipeg and St. Boniface, Manitoba; St. Thomas, Ontario; and Montreal and Lachine, Quebec. Loose-fill insulation consumed 72% of production and insulating concrete and plaster most of the remainder.[2]

China, Peoples' Republic of.—Vermiculite was mined at 20 locations in Linshu County, Shantung Province. A plant was completed in the county to make heat-insulating bricks and slabs by bonding vermiculite with cement.

South Africa, Republic of.—Principal countries to which crude ore was exported in 1972 were the United Kingdom, 22%; the United States, 19%; Italy, 15%; West Germany, 10%; France, 10%; and Japan, 6%.

[2] Stonehouse, D. H. Lightweight Aggregates, 1972. Dept. Energy, Mines, and Resources, Ottawa, July 1973, 4 pp.

Table 2.—Republic of South Africa: Exports of vermiculite by country

(Short tons)

Country	1971	1972	1973
Australia	4,616	3,176	NA
Belgium	917	1,461	
Canada	6,926	5,103	
Finland	917	1,011	
France	12,771	14,763	
Germany, West	13,176	13,941	
Ireland	1,442	1,019	
Israel	--	1,075	
Italy	23,186	20,935	
Japan	9,820	8,522	
Netherlands	1,251	1,153	
New Zealand	668	--	
Spain	4,231	4,938	
Sweden	2,294	2,652	
Switzerland	947	1,078	
United Kingdom	31,975	31,461	
United States	18,130	26,448	
Undisclosed	3,023	3,390	
Total	136,290	r 142,126	157,491
Total value [1]	$3,147,050	r $3,715,372	$4,791,597
Average value per ton [1]	$23.09	$26.14	$30.42

r Revised. NA Not available.

[1] Converted to U.S. currency at the rate of 1 rand equals U.S. $1.40.

Table 3.—Vermiculite: Free world production by country

(Short tons)

Country	1971	1972	1973 p
Argentina	4,727	4,572	e 4,600
Brazil e	5,000	5,000	5,000
India	592	1,699	3,031
Kenya	1,498	1,027	960
South Africa, Republic of	145,582	163,035	172,469
Tanzania	r 32	--	--
United States (sold or used by producers)	301,483	336,798	365,000
Total	r 458,914	512,131	551,060

e Estimate. p Preliminary. r Revised.

TECHNOLOGY

Canadian research showed that exfoliated vermiculite was effective in purifying the air in underground uranium mines by filtering out dust particles and radon daughters. Vermiculite was chosen as the filter medium because of its low cost, low density, and ability to stand high humidity.[3]

[3] Washington, R. A., W. Chi, and R. Regan. The Use of Vermiculite to Control Dust and Radon Daughters in Underground Uranium Mine Air. Can. Min. and Met. Bull., v. 66, No. 731, March 1973, pp. 152–155.

Table 4.—Vermiculite exfoliating plants in the United States in 1973

Company	State	County	Nearest city or town
Ari-Zonolite Co	Arizona	Maricopa	Phoenix.
J. P. Austin Assoc., Inc	Pennsylvania	Beaver	Beaver Falls.
J. J. Brouk & Co., Inc	Missouri	St. Louis	St. Louis.
Carolina Wholesale Florists, Inc	North Carolina	Lee	Sanford.
Certain-teed Products Corp., Building Materials Div.	Minnesota	Hennepin	Minneapolis.
Cleveland Building Materials Supply Co., Cleveland Gypsum Co. Div.	Ohio	Cuyahoga	Cleveland.
W. R. Grace & Co., Construction Products Div.	Arkansas	Pulaski	North Little Rock.
	California	Alameda	Newark.
		Los Angeles	Los Angeles.
		Orange	Santa Ana.
	Colorado	Denver	Denver.
	Florida	Broward	Pompano Beach.
		Duval	Jacksonville.
		Hillsborough	Tampa.
	Illinois	Cook	Chicago.
	Kentucky	Campbell	Newport.
	Louisiana	Orleans	New Orleans.
	Maryland	Prince Georges	Muirkirk.
	Massachusetts	Hampshire	Easthampton.
	Michigan	Wayne	Dearborn.
	Minnesota	Hennepin	Minneapolis.
	Missouri	St. Louis	St. Louis.
	Nebraska	Douglas	Omaha.
	New Jersey	Mercer	Trenton.
	New York	Cayuga	Weedsport.
	North Carolina	Guilford	High Point.
	Oregon	Multnomah	Portland.
	Pennsylvania	Lawrence	New Castle.
	South Carolina	Greenville	Travelers Rest.
		Laurens	Enoree.
	Tennessee	Davidson	Nashville.
	Washington	Spokane	Spokane.
	Wisconsin	Milwaukee	Milwaukee.
Hyzer & Lewellen	Pennsylvania	Bucks	Southampton.
International Vermiculite Co	Illinois	Macoupin	Girard.
Koos, Inc	Wisconsin	Kenosha	Kenosha.
La Habra Products, Inc	California	Orange	Anaheim.
McArthur Co	Minnesota	Ramsey	St. Paul.
Mica Pellets, Inc	Illinois	De Kalb	De Kalb.
B. F. Nelson Manufacturing Co	Minnesota	Hennepin	Minneapolis.
Patterson Vermiculite Co	South Carolina	Laurens	Lanford.
Robinson Insulation Co	Montana	Cascade	Great Falls.
	North Dakota	Ward	Minot.
Schmelzer Sales Associates, Inc	Florida	Hillsborough	Tampa.
The Schundler Co	New Jersey	Middlesex	Edison.
Southwest Vermiculite Co	New Mexico	Bernalillo	Albuquerque.
Strong-Lite Products	Arkansas	Jefferson	Pine Bluff.
Supreme Perlite Co	Oregon	Multnomah	Portland.
Texas Vermiculite Co	Oklahoma	Oklahoma	Oklahoma City.
	Texas	Bexar	San Antonio.
		Dallas	Dallas.
Vermiculite of Hawaii, Inc	Hawaii	Honolulu	Honolulu.
Vermiculite Industrial Corp	Pennsylvania	Allegheny	Pittsburgh.
Vermiculite-Intermountain, Inc	Utah	Salt Lake	Salt Lake City.
Vermiculite Products, Inc	Texas	Harris	Houston.

Zinc

By Albert D. McMahon,[1] John M. Hague,[2] and Herbert R. Babitzke [1]

In many ways 1973 was an outstanding year for zinc in the United States. Highs and lows for items of supply and demand were established, and unique situations developed. It was the best year on record for slab zinc consumption and the worst year for slab zinc production; it was the lowest and highest year for imports of concentrates and metal, respectively; the highest for stockpile releases and exports of concentrates and metal; and prices rose to record levels in both U.S. and world markets. The Government ceiling price control of zinc, administered by the Cost of Living Council, was on and off twice, and the shortage of zinc continued throughout the year. Of the 98 mines accounting for zinc mine production in the United States, the leading 25 mines produced 93% of the total. Missouri, with its byproduct zinc from lead mines in the fairly new southeast lead belt, became the leading zinc-producing State, while Tennessee and New York fell back owing to strikes and operating problems.

Smelter production of slab zinc declined 11% because of a decrease in zinc concentrate imports and the use of more domestic concentrates for American-process zinc oxide. This loss of raw material for the smelters was partially compensated by acquisitions of slab zinc from the national stockpile for remelting and direct shipment to consumers. Closure of the horizontal retort smelter at Amarillo, Tex., was delayed as the Texas Air Control Board rescinded a previous order and issued a variance permitting operations to continue until May 30, 1975. The State of Oklahoma in a similar action extended the variance for the horizontal zinc smelter at Bartlesville, Okla., until June 30, 1975, when it will be replaced by an electrolytic plant. Rehabilitation of the Sauget, Ill., electrolytic plant was completed, and erection of two new plants with a combined annual capacity of 340,000 tons of slab zinc was being considered.

Demand continued to rise through most of the year at a rate of almost 8%. However, because of a slowdown in the last 2 months, the year ended with only a 6% increase over that of 1972.

The major sources of zinc concentrate imports continued to supply less zinc for domestic smelters, but imports of metal increased 13%. Exports of concentrate and metal increased to take advantage of higher prices in the world market. The lead and zinc flexible-tariff bill and the bill to suspend the duty on imports of zinc concentrates were reintroduced in Congress. Both bills were in the House Ways and Means Committee at yearend.

Under the Administration's plan to reduce objectives for most stockpiled materials, that for zinc was lowered from 560,000 to 202,700 tons, creating an additional surplus of 357,300 tons. New legislation authorizing disposal of this quantity was signed by the President on December 28, 1973.

Phase 3 of the President's economic stabilization program effective January 11, 1973, abolished the Price Commission and established voluntary controls subject to the Cost of Living Council regulations. Prices advanced from a range of 18–18.52 cents per pound to 20.25–21 cents, where they were frozen June 13 by Presidential order. The ceiling prices prevailed until December 6, 1973, when the Cost of Living Council abolished Government price control on zinc. The domestic price advanced immediately to a range of 28–32 cents per pound.

Legislation and Government Programs.—The General Services Administration (GSA)

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sold 266,315 short tons of zinc from the stockpile during 1973. Government agencies received 117 tons, which was transferred under authorization of Public Law 89–9, leaving a balance of 21,980 short tons. Commercial sales totaled 266,198 tons as authorized by Public Law 92–283 of April 26, 1972. Of the latter amount, 62,477 tons was sold under the set-aside program, and 204,923 tons was sold to the seven participating primary zinc producers under terms of their long-term contracts. At yearend there remained under Public Law 92–283 approximately 30,085 tons of zinc to be released through primary domestic producers and 25,000 tons in the set-aside program. Based on inventory, actual movement of zinc from the stockpile in 1973 was 272,574 tons. This amount includes the drawdown of some of the zinc that was transferred to the Treasury Department in 1970.

By June 30, 1973, all the zinc that was provided for the initial 75,000-ton set-aside program was sold; therefore, on July 1, 1973, the set-aside program was revised upwards to allow releases of 25,000 tons of zinc per quarter as long as zinc remained in the authorization and at the same time allowing the primary producers to draw more zinc. In the revised program, 5,000 tons of Special High Grade zinc was provided, and consumers were limited to purchases of 120 tons of Special High Grade per quarter or 480 tons of High Grade, Intermediate, or Prime Western. On every quarterly allocation the consumers ordered more zinc than what was made available; consequently, the orders were reduced in proportion to what was available.

In April, the stockpile objective for zinc was reduced from 560,000 tons to 202,700 tons, which created a surplus of 357,300 tons. New legislation, Public Law 93–212, authorizing disposal of this quantity was signed by the President on December 28, 1973. This bill provided that 150,000 tons of zinc be sold direct to the consumers, 75,000 tons during the second quarter of 1974 and 25,000 tons each following quarter for the balance. The remaining 207,300 tons was for the participating primary zinc producers.

The President's economic stabilization program entered phase 3 on January 11, 1973, which removed the mandatory price ceiling on zinc and allowed limited price increases, but on June 13, 1973, phase 4 was established by Presidential order which froze the price of zinc once again. This status remained until December 6, 1973, when the Cost of Living Council was abolished and zinc pricing was decontrolled.

The lead and zinc flexible-tariff bill and the bill to suspend the duty on imports of zinc concentrates were reintroduced in Congress in March 1973. Each incorporated a significant change from the previous bills. The new flexible-tariff bill permitted a larger quantity of zinc metal to enter the United States before the high duties became effective, and the duty suspension bill on zinc concentrates was for 2 years. At yearend, both bills were in the House Ways and Means Committee. Another bill, also in the House Ways and Means Committee, proposed suspension of the duty on imports of zinc metal.

The International Lead and Zinc Study Group held its 17th session in Geneva from November 7–12, 1973, to review developments leading to the current situation and the outlook for these metals. Representatives from 28 of the 30 member countries attended. Representatives of several intergovernmental organizations were also present. The strong growth in zinc consumption featured in 1972 continued through most of 1973, but a slowdown in the rate of growth was forecast for 1974. The 1973 forecasts for mine and metal production were adjusted to increases of 3% and 5%, respectively, over 1972 production; zinc metal consumption, rising strongly in most countries, was expected to register an increase of 10%, following one of 11% in 1972. Producers' stocks were drawn down to very low levels, and a large statistical deficit developed. This situation was expected to continue into 1974. The various price rulings throughout the world created a complex basis for zinc sales. In the United States domestic production was subject to Government price control, substantially under world markets at 20.25 to 21 cents per pound, but imported metal was sold in the United States at much higher levels. The European producer price increased in stages to 31.54 cents per pound, while the London Metal Exchange quotation increased dramatically to over 95 cents per pound. The Statistical Committee set up an ad hoc working party to review the importance of secondary materials as a source for lead and zinc. Other topics discussed at the meeting included new mine and smelter projects, consumption trends, trade liberalization, and long-term projections.

Table 1.—Salient zinc statistics

	1969	1970	1971	1972	1973
United States:					
Production:					
Domestic ores, recoverable content short tons	553,124	534,136	502,543	478,318	478,850
Value thousands	$161,512	$163,650	$161,819	$169,803	$197,861
Slab zinc:					
From domestic ores short tons	458,754	403,953	403,750	400,969	365,307
From foreign ores do	581,843	473,858	362,683	232,211	176,012
From scrap do	70,553	77,156	80,923	73,718	87,466
Total do	1,111,150	954,967	847,356	706,898	628,785
Secondary zinc [1] do	307,714	264,074	279,399	r 314,043	300,073
Exports of slab zinc do	9,298	288	13,346	4,324	14,566
Imports (general):					
Ores (zinc content) do	602,120	525,759	342,521	254,868	199,053
Slab zinc do	324,776	270,413	319,568	522,612	588,725
Stocks, December 31:					
At producer plants do	65,788	98,314	41,220	21,181	20,291
At consumer plants do	102,007	92,674	91,523	r 124,956	114,317
Government stockpile do	1,142,185	1,141,490	1,137,937	949,583	677,009
Reprocessed GSA zinc [2]	NA	NA	NA	80,403	109,333
Consumption:					
Slab zinc short tons	1,385,380	1,186,951	1,254,059	1,418,349	1,503,938
All classes do	1,814,167	1,571,596	1,650,694	r 1,844,023	1,931,925
Price: Prime Western [3] cents per pound	14.65	15.32	16.13	17.75	20.66
World:					
Production:					
Mine short tons	5,888,298	6,023,488	r 6,079,365	r 6,220,692	6,377,392
Smelter do	5,482,489	5,320,771	r 5,228,959	r 5,645,989	5,795,352
Price: Prime Western grade, London cents per pound	12.96	13.36	14.08	17.13	38.55

r Revised. NA Not available.
[1] Excludes redistilled slab zinc.
[2] Included in total amount withdrawn from Government stockpile.
[3] 1969–70, East St. Louis price; 1971–73 delivered price.

Table 2.—Zinc statistics, 1900–73
(Short tons except as noted)

Year	World: World smelter production (thousand tons)	World: World mine production (thousand tons)	United States: U.S. smelter production (primary)	U.S. mine production	Imports slab zinc	Imports ore zinc content	Exports metal	Exports ore, zinc content	Slab zinc production from secondary materials	Consumption, slab, apparent primary	Consumption, ore, direct	Price cents per pound E. St. Louis
1900	528	NA	123,886	165,948	884	NA	22,401	42,062	NA	99,399	NA	4.30
1901	563	NA	140,822	184,798	278	NA	3,390	44,156	NA	141,679	NA	4.00
1902	603	NA	156,927	212,660	448	NA	3,237	55,733	NA	152,682	NA	4.76
1903	633	NA	159,219	198,630	202	NA	1,521	39,411	NA	154,381	NA	5.25
1904	693	NA	186,702	222,613	341	NA	10,147	35,911	NA	180,911	NA	5.00
1905	727	NA	203,849	234,795	428	NA	5,516	30,946	NA	200,438	60,305	5.90
1906	776	NA	224,770	221,726	1,021	25,076	4,670	27,720	NA	220,781	66,247	6.20
1907	814	NA	249,860	259,951	1,709	26,115	563	20,352	7,050	226,969	56,931	5.50
1908	797	NA	210,424	234,526	881	19,675	1,233	26,108	7,159	214,167	48,004	4.20
1909	854	NA	255,760	305,423	9,454	25,535	334	12,455	9,273	270,730	54,139	5.40
1910	893	NA	269,184	327,712	1,960	16,705	9,244	19,711	12,784	245,884	50,592	5.40
1911	986	NA	286,526	345,260	3,349	14,905	14,355	18,281	14,043	280,059	46,122	5.70
1912	1,061	NA	338,806	378,816	11,115	14,899	7,505	23,349	26,064	340,341	64,032	6.90
1913	1,119	NA	346,676	406,416	6,100	9,424	13,486	17,713	25,991	295,370	70,622	5.60
1914	966	NA	353,049	415,662	880	9,631	74,510	11,110	20,545	299,983	70,619	5.10
1915	923	NA	489,519	587,595	904	31,384	131,410	832	29,764	364,855	79,572	14.20
1916	1,072	NA	668,343	703,317	684	104,005	206,365	78	28,776	459,317	90,276	13.60
1917	1,095	1,214	669,573	713,359	257	84,976	220,064	1,320	16,835	413,643	97,573	8.90
1918	907	1,031	517,927	636,091	35	25,522	106,650	62	9,918	423,792	102,778	8.00
1919	726	889	465,743	548,846	70	13,471	146,297	--	19,748	323,964	100,210	7.00
1920	796	943	463,377	587,524	8,177	13,332	114,267	--	21,371	323,043	116,979	7.80
1921	520	563	200,500	256,640	7,470	2,268	4,955	--	17,573	203,600	57,229	4.70
1922	784	886	354,277	472,032	52	1,003	34,801	1,695	32,988	373,090	94,913	5.70
1923	1,043	1,080	510,434	610,690	21	2,099	32,943	2,804	39,434	446,514	117,543	6.70
1924	1,105	1,613	517,339	637,977	25	1,508	76,241	368	35,486	448,257	109,357	6.30
1925	1,243	1,492	572,946	710,847	24	13,536	76,351	68,951	39,181	500,097	111,227	7.66
1926	1,343	1,767	618,422	774,563	22	14,567	42,920	95,252	40,799	557,026	129,791	7.37
1927	1,440	1,768	592,516	718,541	59	9,513	45,695	46,716	42,784	516,373	121,946	6.25
1928	1,544	1,754	602,581	695,170	2	1,667	25,289	4,518	48,666	626,500	124,090	6.03
1929	1,599	1,891	625,447	724,478	226	14,411	14,411	71	47,348	634,300	138,104	6.49
1930	1,537	1,727	498,045	595,425	281	25,839	4,633	--	34,849	450,900	104,561	4.56
1931	1,099	1,152	291,996	410,318	274	780	643	13	21,625	370,000	74,532	3.64
1932	861	996	207,148	285,231	310	1,904	6,471	--	14,718	259,000	54,932	2.88
1933	1,084	1,250	307,182	384,280	1,890	2,133	1,145	809	30,087	350,300	71,622	4.03
1934	1,287	1,491	363,590	438,726	1,725	14,277	5,105	3,621	19,691	359,900	76,331	4.16
1935	1,468	1,600	420,634	517,903	4,444	10,520	1,617	461	28,650	473,000	85,722	4.33
1936	1,614	1,777	492,132	575,574	11,660	172	37	245	42,209	582,000	95,991	4.90
1937	1,789	1,930	556,904	626,362	37,208	8,812	249	314	51,554	610,000	111,622	6.52
1938	1,726	1,935	446,341	516,703	7,230	18,583	--	135	31,613	421,000	69,099	4.61

1939 ----	1,819	1,972	507,236	583,807	30,898	36,100	4,515	303	50,428	626,000	84,896	5.12
1940 ----	1,786	2,124	675,275	665,068	16,468	180,320	79,091	448	48,917	733,057	95,917	6.34
1941 ----	1,928	2,284	822,020	749,125	34,554	289,213	89,309	--	59,503	827,435	134,815	7.48
1942 ----	1,984	2,308	891,872	768,025	36,394	368,408	133,938	--	53,195	728,169	115,002	8.25
1943 ----	2,028	2,224	942,309	744,196	56,155	539,049	97,439	1	48,215	816,777	114,700	8.25
1944 ----	1,788	2,270	869,302	718,642	63,626	422,694	21,576	--	49,037	888,626	142,256	8.25
1945 ----	1,435	1,781	764,561	614,358	97,116	381,719	7,782	--	49,242	852,311	130,992	8.25
1946 ----	1,534	1,745	728,262	574,833	104,743	272,056	47,224	89	44,516	810,242	133,995	8.73
1947 ----	1,763	1,950	802,495	637,608	72,312	297,959	106,669	1,404	59,542	786,360	145,923	10.50
1948 ----	1,881	2,048	787,764	629,977	93,232	264,203	65,537	3,547	62,320	817,735	132,649	13.58
1949 ----	2,012	2,105	814,782	593,203	126,925	241,179	58,709	2,925	55,041	711,841	88,142	12.15
1950 ----	2,170	2,370	843,467	623,375	155,974	278,573	12,917	1,140	66,970	967,134	134,434	13.88
1951 ----	2,360	2,600	881,633	681,189	88,043	302,777	36,510	3,090	48,657	933,971	133,845	17.99
1952 ----	2,460	2,850	904,479	666,001	115,705	449,636	57,714	3,370	55,111	852,783	109,277	16.21
1953 ----	2,600	2,940	916,105	547,430	234,576	513,724	17,969	2,953	52,875	985,927	118,244	10.86
1954 ----	2,700	2,930	802,425	473,471	156,858	455,427	24,994	--	68,013	884,299	99,247	10.69
1955 ----	2,930	3,200	963,504	514,671	195,696	478,044	18,069	--	66,042	1,119,812	118,135	12.30
1956 ----	3,100	3,430	983,610	542,340	244,978	525,350	8,813	854	72,127	1,008,790	113,388	13.49
1957 ----	3,200	3,470	985,796	531,735	269,007	526,014	10,785	7	72,481	935,620	110,311	11.40
1958 ----	3,010	3,370	781,246	412,005	195,199	461,560	2,073	--	46,605	868,327	94,938	10.31
1959 ----	3,150	3,440	798,666	425,303	156,963	500,115	11,629	1	57,818	956,197	108,070	11.46
1960 ----	3,335	3,680	799,516	435,427	120,767	457,155	75,144	13	68,731	877,884	88,275	12.95
1961 ----	3,580	3,845	846,795	464,390	127,562	415,700	50,055	1,670	55,237	931,213	97,251	11.55
1962 ----	3,755	3,930	879,395	505,491	141,957	467,398	36,102	136	58,880	1,031,821	101,582	11.63
1963 ----	3,844	4,036	892,584	529,254	144,757	372,769	33,853	17	60,303	1,105,113	104,705	12.01
1964 ----	4,071	4,440	954,084	574,858	118,340	357,145	26,515	39	71,596	1,207,268	105,948	13.57
1965 ----	4,353	4,742	994,402	611,153	152,990	428,040	5,939	NA	83,619	1,354,092	122,892	14.50
1966 ----	4,498	4,942	1,025,066	572,558	278,175	521,320	1,406	NA	83,263	1,423,666	126,696	14.50
1967 ----	4,548	5,330	938,830	549,413	222,112	534,092	16,809	NA	73,505	1,250,673	114,301	13.85
1968 ----	5,101	5,484	1,020,891	529,446	304,576	543,366	33,011	NA	79,865	1,350,656	124,109	13.50
1969 ----	5,482	5,888	1,040,597	553,124	324,776	602,120	9,298	NA	70,553	1,385,380	126,712	14.65
1970 ----	5,321	6,023	877,811	534,136	270,413	525,759	288	NA	77,156	1,186,951	124,781	15.32
1971 ----	5,229	6,079	766,433	502,543	319,568	342,521	13,346	NA	80,923	1,254,059	119,254	[1] 16.13
1972 ----	5,646	6,221	633,180	478,318	522,612	254,868	4,324	NA	73,718	1,418,349	118,305	[1] 17.75
1973 ----	5,795	6,377	541,319	478,850	588,725	199,053	14,566	NA	87,466	1,503,938	129,651	[1] 20.66

NA Not available.
[1] Delivered.

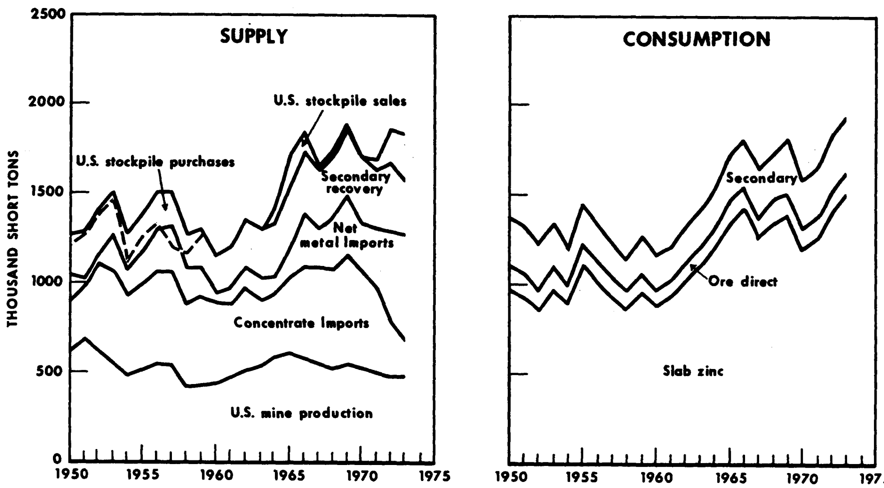

Figure 1.—Trends in supply and consumption in the United States.

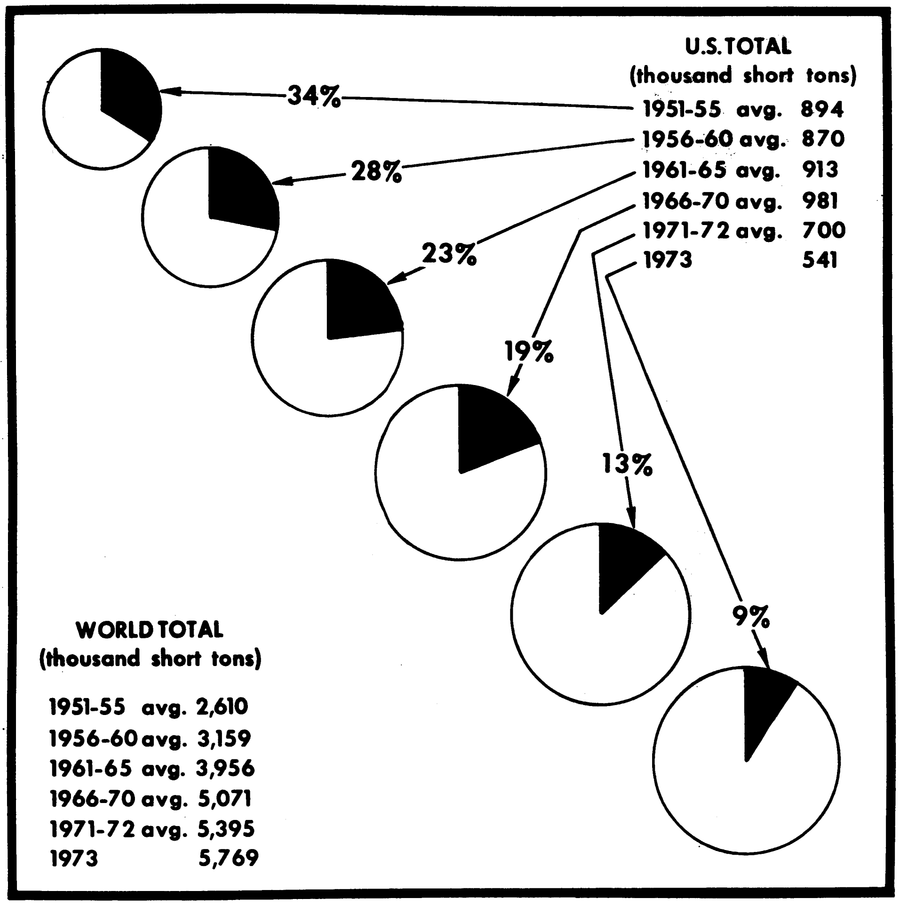

Figure 2.—Trends of United States percentage of World smelter production.

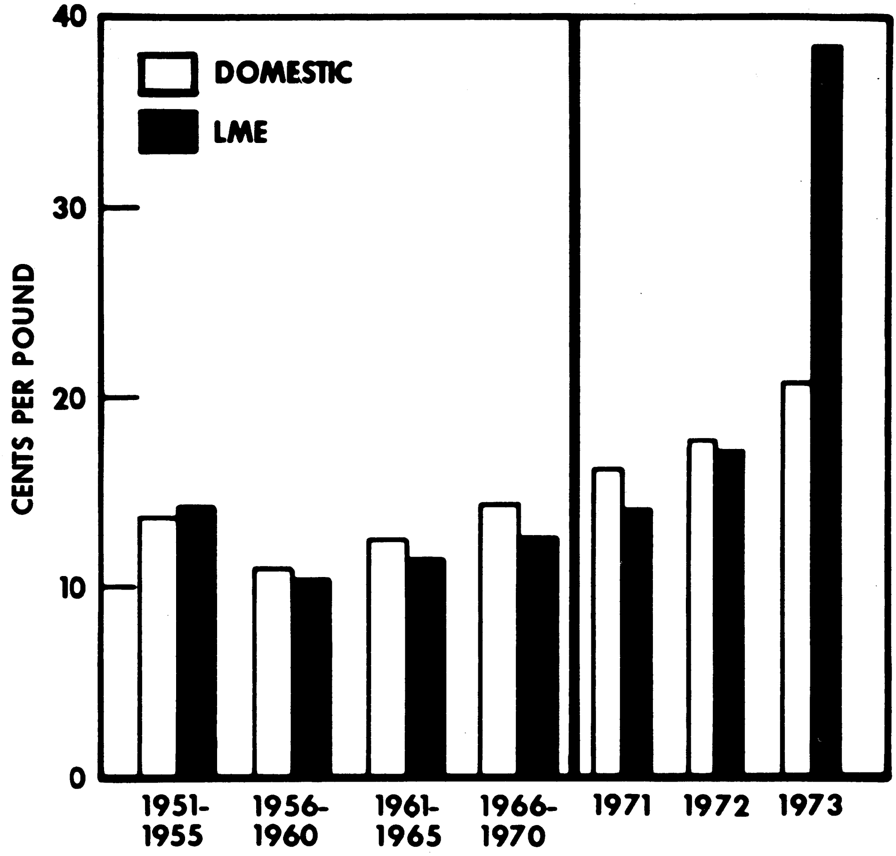

Figure 3.—Trends in foreign and domestic zinc prices.

DOMESTIC PRODUCTION

MINE PRODUCTION

Mines in the United States produced 478,850 tons of recoverable zinc, 532 tons more than in 1972 and the first increase since 1969. Production was reported in 18 States. Seven States recorded increases over that of 1972, and 11 States registered decreases. Missouri with its byproduct zinc recovery from lead ores led the Nation in zinc production with 33% more than in 1972. New York moved up into second place with a 34% increase, and Tennessee dropped to third with a decline of 37%. Colorado, Idaho, and New Jersey followed in order, repeating the 1972 pattern. The States east of the Mississippi River accounted for 52% of the U.S. 1973 mine production.

Sources of zinc production for 1973 are shown in table 5 according to the principal metal or combination of metals extracted. The percentage distribution is as follows: Zinc ore, 57%; zinc-lead ore, 19%; lead ores, 18%; copper-zinc and copper-lead-zinc ores, 5%; all other sources, 1%.

The 25 leading mines listed in table 6 accounted for 93% of the domestic recoverable mine production. The five leading mines produced 43%, and the first 10 mined 63%.

Missouri attained first place among the zinc-producing States with a 33% increase over 1972. Byproduct zinc production from St. Joe Minerals Corp.'s four operating lead mines in the New Lead Belt in southeast Missouri (Fletcher, Viburnum, Indian Creek, and Brushy Creek) increased in 1973, and more is expected in 1974. The mills at Fletcher and Brushy Creek are among the most modern in the industry and incorporate computer-controlled processes allowing the entire plant to be operated by only a few employees.[3] The Missouri mine-mill-smelter complex, owned jointly by American Metal Climax, Inc. (AMAX) and Homestake Mining Co., benefited from higher production, favorable ore grade, and higher prices. About 1.6 million tons of ore were mined and milled in 1973, an increase of 10% over 1972. Production of zinc concentrate was up 42% to 116,500 tons.[4] The Magmont mine at Bixby, Mo., operated by Cominco American Incorporated, a joint venture of Cominco, Ltd. and Dresser Industries, Inc., produced 934,000 tons of ore averaging 8.3% combined lead and zinc compared with 1,034,000 tons of 7.9% ore in 1972. Except for a 1-month strike in June, a high level of production was maintained throughout the year.[5]

Byproduct zinc output by the Ozark Lead Co. was lower in 1973 because of a 2-month strike which ended on April 30 with agreement on a 3-year labor contract. A shortage of skilled underground maintenance personnel also adversely affected production. In 1973, Ozark Lead Co. was awarded the national Sentinels of Safety trophy for outstanding underground mine safety performance. This award is sponsored by the Bureau of Mines and the American Mining Congress. Ozark was honored for the second consecutive year—the first time a U.S. mine has achieved that distinction since 1928.[6]

Mine production in New York, all from the Balmat-Edwards mining complex of St. Joe Minerals Corp., increased 34% in 1973, and higher production is expected in 1974. St. Joe has concentrated on exploration and continued the modernization and underground development programs at the Balmat-Edwards mines. Two mills treat 5,000 tons of ore per day and produce a 55% zinc concentrate. The Balmat mill has over 85% of that capacity and is one of the most automated mills in the world.[7]

Tennessee dropped to third place after ranking first among the mine-producing States for 15 years. The decline of 37% was due principally to the closure of three mines for 8 months by a strike. Occidental Mineral Corp. (Oxymin), a subsidiary of Occidental Petroleum Corp., increased its leaseholdings in the vicinity of Carthage, Tenn., to a total of 1,300 acres. Further exploration and development are being discussed with several mining companies.[8]

The New Jersey Zinc Co.'s newest mine, in Elmwood, Tenn., is scheduled to begin initial production in the spring of 1974.[9]

The Jefferson City mine of New Jersey Zinc Co. and the Zinc Mine Works of United States Steel Corp. in east Tennessee operated throughout the year. American Smelting and Refining Company (ASARCO) started construction on a new concentrator at the Young mine in December. It will be more modern and 20% larger than the Mascot mill.[10]

Operational problems continued at the industrial chemicals plant at Cities Service Co., at Copperhill, Tenn., which had been revamped and expanded. Zinc concentrate sales increased 71% in 1973 to 18,100 tons.[11]

Production in New Jersey, Pennsylvania, and Virginia by New Jersey Zinc Co. declined for the third straight year to 68,567 tons, 6.4% below that of 1972. This company is continuing an active exploration program for additional minerals with emphasis on zinc-bearing ores. Significant progress was made in deepening the shaft at the Friedensville, Pa., mine.[12]

In Colorado, mine output decreased in 1973 to 58,339 tons, a decline of 8.6% below that of 1972. The New Jersey Zinc Co. Eagle mine produced the largest tonnage of zinc, although slightly less than in 1972. The Resurrection mine, a joint venture shared equally by Resurrection Mining Co. (a 100% owned subsidiary of Newmont Mining Corp.) and ASARCO, continued operation without interruption during the year. The mine produced only about 75% of its rated capacity of 700 tons of ore per

[3] St. Joe Minerals Corp. 1973 Annual Report. P. 7.
[4] American Metal Climax, Inc. 1973 Annual Report. P. 16.
[5] Cominco, Ltd. 1973 Annual Report. P. 9.
[6] Kennecott Copper Corp. 1973 Annual Report. Pp. 11 and 22.
[7] Page 11 of work cited in footnote 3.
[8] Occidental Petroleum Corp. 1973 Annual Report. P. 17.
[9] Gulf & Western Industries, Inc. 1973 Annual Report. P. 31.
[10] American Smelting and Refining Company. 1973 Annual Report. P. 8.
[11] Cities Service Co. 1973 Annual Report. Pp. 2 and 30.
[12] Page 31 of work cited in footnote 9.

day, due largely to a manpower shortage. However, because of an increase in ore grade, higher metal prices, and carefully controlled costs, the mine, operated by ASARCO, had a profitable year. The average grade of ore milled in 1973 was 8.95% zinc, 3.96% lead, 2.8 ounces of silver, and 0.07 ounce of gold per ton, compared with 7.6% zinc, 3.9% lead, 2.4 ounces of silver, and 0.07 ounce of gold per ton in 1972. Ore reserves as of January 1, 1974, were estimated at 2,619,000 tons averaging 9.71% zinc, 4.98% lead, 2.53 ounces of silver, and 0.067 ounce of gold per ton, compared with 2,609,500 tons averaging 9.92% zinc, 5.16% lead, 2.53 ounces of silver, and 0.068 ounce of gold per ton at yearend 1972. The Newmont Mining Corp. Idarado mine was the third largest producer in Colorado, and the Sunnyside mine of Standard Metals Corp. ranked fourth. Idarado's 1973 tonnage milled was only slightly below that of 1972. Additional income from higher metal prices in 1973 was offset by higher operating costs and by increased development expenses required to open more stopes and add to broken ore reserves. In 1973, the mill treated 378,150 tons of ore averaging 3.44% zinc, 2.55% lead, 0.56% copper, 1.39 ounces of silver, and 0.052 ounce of gold per ton. This compares with 386,500 tons milled in 1972 averaging 3.74% zinc, 2.74% lead, 0.72% copper, 1.74 ounces of silver, and 0.063 ounce of gold per ton. Ore reserves at the end of 1973 were 3,241,000 tons averaging 4.61% zinc, 3.36% lead, 0.77% copper, 1.77 ounces of silver, and 0.02 ounce of gold per ton, compared with 2,865,000 tons in 1972 containing averages of 4.80% zinc, 3.31% lead, 0.74% copper, 1.75 ounces of silver, and 0.03 ounce of gold per ton.[13]

Mine production of zinc in Maine increased to 19,640 tons as the Blue Hill mine completed its first full year of operation. The ore body is a difficult one to mine, and at yearend the designed production of 1,000 tons per day had not been attained over a 7-day-per-week basis. Milling throughout the year was restricted to 5 days per week owing to the inability to develop enough ore faces in the mine for a greater production rate. During 1973, 230,200 tons of ore averaging 10.69% zinc and 0.63% copper was milled to produce 885 tons of copper and 23,030 tons of zinc in separate concentrates. Minable ore reserves, including an allowance for dilution and based on past mining experience, on December 31, 1973, were estimated to be 742,000 tons grading 5.68% zinc and 1.7% copper.[14]

Mine production of zinc in Idaho for 1973 increased 19% to 46,107 tons. Ore production at the Bunker Hill mine increased about 17%, reflecting greater production of zinc ores from the upper levels of the mine which have been under development for the last 2 years. Zinc metal content of ore increased 25%, while lead and silver remained unchanged from 1972. Ore reserves were nearly the same as in 1972 with the development of new reserves to replace those mined during the year. The intensified mine exploration program, which began in 1973, is on schedule and will continue for 4 more years. Gross production from the Star mine equaled that of 1972, although zinc production was off by 8%. Higher metal prices more than offset rising operating costs, and the mine experienced its first profitable year since 1967. In 1973 production from company owned and controlled mines amounted to 38,000 tons of zinc, 31,000 tons of lead, and 2.6 million ounces of silver.[15] The Star-Morning mine, 30% owned by Hecla Mining Co. and 70% owned by the Bunker Hill Co., produced 265,781 tons of ore in 1973 assaying 6.68% zinc, 5.18% lead, and 2.79 ounces of silver per ton compared with 263,595 tons in 1972 containing 7.36% zinc, 5.33% lead, and 2.87 ounces of silver per ton.[16] During 1973 an independent contractor operating the Day Mines, Inc., Monitor mine produced 20,674 tons of ore averaging 7.90% zinc, 2.71% lead, and 0.86 ounce of silver per ton from the Gray Rock section. Ore reserves were increased to provide adequate ore for an additional 3 years of production at the current rate.[17]

Mine production of zinc in Utah declined 23%. Zinc, lead, and silver production at the Kennecott Copper Corp. Tintic Division (Utah) decreased in 1973 owing to a critical shortage of skilled miners and mechanics. Also, adverse underground mining conditions inhibited development work and production.[18]

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13 Newmont Mining Corp. 1973 Annual Report. Pp. 9–10.
14 Kerr Addison Mines Limited. 1973 Annual Report. Pp. 1–6.
15 Gulf Resources & Chemical Corp. 1973 Annual Report. P. 7.
16 Hecla Mining Co. 1973 Annual Report. P. 7.
17 Day Mines, Inc. 1973 Annual Report. P. 3.
18 Kennecott Copper Corp. 1973 Annual Report. P. 11.

Zinc mine production in Arizona for 1973 was 17% lower than in 1972. The Bruce mine near Bagdad, Ariz., is operated by the Cyprus Bruce Copper and Zinc Co., a wholly owned division of Cyprus Mines Corp. In 1973, mine output of ore was 93,000 tons with an average grade of 12.7% zinc and 3.68% copper. Concentrates produced contained 3,000 tons of copper and 9,500 tons of zinc. Record earnings were achieved owing to good metallurgical results, acceptable production costs, and high average prices received for copper, 60.8 cents per pound, and zinc, 26.4 cents per pound. Exploration did not add much to known reserves, but surface and underground drilling will continue in 1974. Known ore reserves of 467,000 tons with an average grade of 12.4% zinc and 3.72% copper will sustain the operation for about 5 years.[19]

In 1973, mine output of zinc in New Mexico declined 3% from that in 1972. At the ASARCO Ground Hog mine, the zinc content of ore produced was 13,500 tons, compared with 14,000 tons in 1972.[20] UV Industries, Inc., anticipates some zinc production from the reopening of the Hanover mine in New Mexico. Byproduct zinc will be recovered from the copper ore processed at the Continental Mill No. 1 at Bayard, N. Mex. A 2-year program will define the extent of the copper, iron, and zinc reserves.[21]

In Washington, 1973 mine production dropped slightly to 6,378 tons. Pend Oreille Mines & Metals Co. mined and milled 212,289 tons of ore and produced 10,834 tons of zinc concentrate. Development of the Yellowhead Area is underway with several headings being driven from the Yellowhead Exploration Decline. Several areas of low- to high-grade lead-zinc ore have been intercepted, but continuity of mineralization is still a problem that precludes making an accurate estimate of minable ore reserves.[22]

The Callahan Mining Corp. has resumed work at its zinc-lead property near Colville, Wash., under an agreement reached in the last quarter of 1973 granting United States Borax & Chemical Corp. and the British Newfoundland Exploration Ltd. the right to earn jointly up to 51% interest in the property through work expenditures. The program, which will include geologic work and drilling during 1974, is designed to test potential for increasing ore reserves indicated by prior surface drilling and underground test work.[23]

Wisconsin mine production of zinc increased 26% in 1973. In Illinois and Kentucky production decreased 54% and 85%, respectively.

SMELTER AND REFINERY PRODUCTION

U.S. slab zinc production at smelters and electrolytic plants was 628,785 short tons in 1973, a decrease of 11% from that of 1972. The decline may be attributed to the closure of the horizontal retort smelter at Blackwell, Okla., the inability of the AMAX plant at Sauget, Ill. to come on full stream during the year, a decrease in imports of zinc concentrates, and the use of more domestic concentrates for American process zinc oxide.

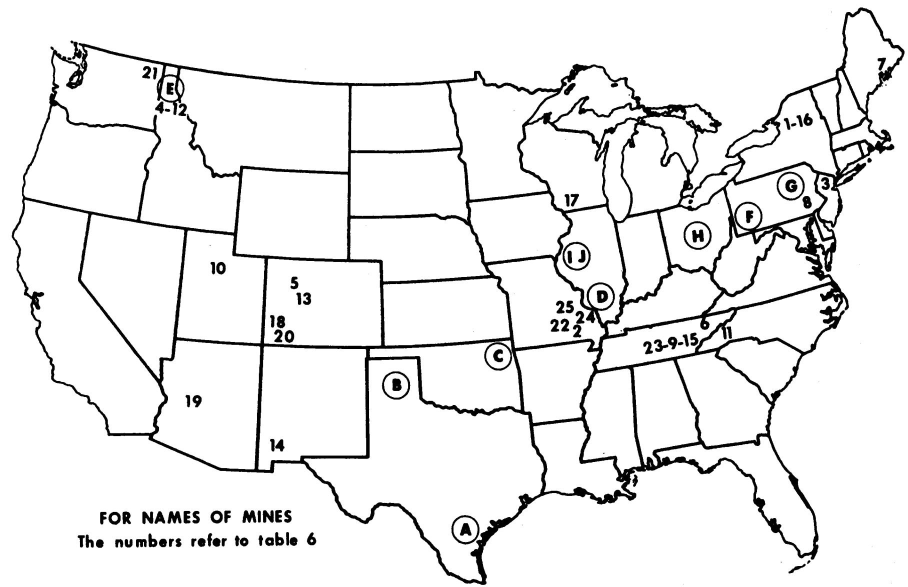
Drawdown of producers' stocks was minor for the year. Ending stocks at producer plants were 20,291 tons. In addition to the slab zinc production, producers purchased 154,327 tons of GSA stockpile zinc during the year; 44,994 tons was shipped directly to customers, and 109,333 tons was remelted for upgrading.

Smelter and refinery capacities were increased 28,000 tons during the year to 749,500 tons. This increased capacity may be attributed to the startup of the AMAX Zinc Co., Inc., at Sauget, Ill., and the expansion of St. Joe Minerals Corp. at Monaca, Pa.

Refined zinc production at primary smelters and electrolytic refineries was derived from the following: Domestic ore, 58%; foreign ore, 28%; and scrap, 14%. Slab zinc produced from domestic and foreign ore decreased 9% and 24%, respectively, from that of 1972, but that produced from scrap increased 19%.

Primary slab zinc produced at electrolytic plants was 19% less than that in 1972 and was 33% of the total slab zinc produced. Smelter production (distilled) was down 11% and made up 53% of the total. Redistilled slab zinc from secondary zinc materials by primary smelters increased 2% and contributed 10% of the total, and redistilled production at secondary plants

[19] Cyprus Mines Corp. 1973 Annual Report. Pp. 9–10.
[20] Page 20 of work cited in footnote 10.
[21] UV Industries, Inc. 1973 Annual Report. P. 3.
[22] Pend Oreille Mines & Metals Co. Report to Shareholders. Feb. 14, 1974, p. 1.
[23] Callahan Mining Corp. 1973 Annual Report. P. 6.



SMELTING AND REFINING LOCATIONS

A. ASARCO-Corpus Christi, Texas
B. ASARCO-Amarillo, Texas
C. National Zinc Co. Bartlesville, Okla.
D. AMAX Zinc Co. Sauget, Ill.
E. Bunker Hill Co. Kellogg, Idaho
F. St. Joe Minerals Co. Monaca, Pa.
G. New Jersey Zinc Co. Palmerton, Pa.
H. ASARCO–Columbus, Ohio (oxide)
I. ASARCO–Hillsboro, Ill. (oxide)
J. Eagle Picher Industries, Hillsboro, Ill. (oxide)

Figure 4.—Locations of the zinc smelters and the 25 leading zinc producing mines in the United States.

more than doubled over that of 1972 and was 4% of the total. Production of all grades of zinc declined except for a 9% increase for Prime Western. Distribution of the total grades was as follows: Special High, 40%; High, 4%; Intermediate, 6%; Brass Special, 10%; and Prime Western, 40%.

ASARCO is considering the construction of an electrolytic zinc refinery on 1,400 acres of land on the Ohio River, near Stephensport, Ky. If undertaken, the plant would be completed by 1976 and would produce about 180,000 tons of zinc per year and significant byproduct sulfuric acid and cadmium. ASARCO's reasons for choosing the Stephensport area were the availability of rail and river barge transportation at the plant site, and its closeness to both ASARCO Tennessee zinc mines and the principal Midwestern markets for refined zinc and sulfuric acid.[24] The cost for construction of the plant was revised upward to $150 million, up $50 million from a previous estimate.[25]

During 1973, ASARCO installed an electric melting furnace at its electrolytic zinc plant in Corpus Christi, Tex., to provide a cleaner and more efficient operation than was possible with the two gas-fired reverberatory furnaces which it replaced. The $3.7 million program to convert from in-plant generation of electric power to purchased power continued and is expected to be completed in 1974. Regarding the Amarillo, Tex., plant, a variance was granted in July by the Texas Air Control Board to allow the plant to operate until May 30, 1975. The operation will be phased out at that time, or shortly thereafter, as the expenditures necessary to meet the applicable air quality standards are not justified at this horizontal retort zinc smelter.[26]

The Sauget, Ill., electrolytic zinc plant, purchased by AMAX in 1972, underwent extensive rehabilitation with initial production commencing in May 1973. A total of 25,000 tons of refined zinc was produced for the year, and an output of 70,000 tons is expected in 1974. Full capacity of 84,000 tons of zinc should be reached by 1975, and an annual production of 1.35 million pounds of cadmium and 150,000 tons of sulfuric acid is also expected. Completion of preleach facilities late in 1974 will permit the processing of high-magnesium-bearing zinc concentrates. At full production, the Sauget plant will represent about 12% of total U.S. zinc smelter capacity.

By the end of 1973, the planned phase-out of the AMAX Blackwell, Okla., horizontal retort furnaces was completed, although sintering operations were to continue through the first part of 1974. Production in 1973 totaled 39,000 tons of zinc. The change in basic product grade, from Prime Western zinc produced at Blackwell to Special High Grade produced at Sauget, will provide AMAX with additional capability to supply zinc to the die-casting and to other premium markets.[27]

St. Joe Minerals Corp., the Nation's largest zinc smelter, which provides about one-third of the domestic zinc, produced 231,085 tons of zinc (zinc equivalent) in 1973, slightly less than that of 1972 and under its 245,000-ton capacity. An expansion program has begun at the smelter that will increase the annual capacity by 40,000 tons in 1976. During the year the zinc smelter phased out its production of Special High Grade zinc alloys in order to concentrate its productive capacity on the fast-growing zinc oxide field and on a full line of zinc metal for the galvanizing industry.

Zinc oxide has become an increasingly important product for St. Joe Minerals Corp., now the second largest producer in the United States. Production in 1973 was 62,000 tons and it is expected to go over 70,000 tons in 1974. An expansion program is underway with an investment of approximately $5 million to increase the zinc oxide facilities to 85,000 tons. The full amount of this capacity should be on line in late 1974.

In 1973 capital expenditures for environmental improvement at the Monaca, Pa., smelter totaled $5.2 million. An additional $6 million will be spent in 1974 in the continuing program to keep the zinc smelter in full compliance with Federal and State air and water environmental regulations.[28]

The New Jersey Zinc Co. reported an increase of 28% to $130.5 million in net sales for fiscal 1973. Zinc metal production was 103,000 tons, up 6% over that of fiscal

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[24] Engineering and Mining Journal. ASARCO To Build Large Zinc Refinery on Ohio River. V. 174, No. 5, May 1973, p. 24.

[25] Metals Week. Elsewhere in Lead and Zinc. V. 45, No. 17, Apr. 29, 1974, p. 3.

[26] Page 14 of work cited in footnote 10.

[27] Page 18 of work cited in footnote 4.

[28] Pages 3 and 18 of work cited in footnote 3.

1972, while pigment production was 177,000 tons, an increase of 20%. The strong demand for zinc metal and oxides, combined with reduced U.S. production capacity, contributed to a maximum level of operations.[29]

The New Jersey Zinc Co. announced that it is considering building an electrolytic zinc refinery and a zinc oxide plant near Clarksville, Tenn., and modernizing its Palmerton, Pa., zinc plant. If undertaken, the Clarksville refinery would begin production in 1977, and by 1979 the plant should have an annual capacity of 160,000 tons. The new plant would use zinc concentrates produced at company mines in Tennessee and Virginia. The modernization program at Palmerton includes improved mix houses, modifications of the roasting and acid plant, mechanization of bagroom oxide handling, revisions of materials handling systems, and new dust-control facilities. The modernization program will also increase production capacity for French process and American process zinc oxide.[30]

The Bunker Hill Co., a division of Gulf Resources & Chemical Corp., of Kellogg, Idaho, produced 98,300 tons of zinc in 1973, down from 101,700 tons in 1972. The annual capacity of the zinc plant is approximately 104,000 tons. The drop in production was caused by a work stoppage and by domestic price controls which made it difficult to compete successfully in world ore markets for quality concentrates. Total net sales in 1973 were $102.4 million, compared with $91.9 million in 1972.

The Bunker Hill Co. continued work with the Bureau of Mines on construction of a plant adjacent to the smelter for large-scale testing of the Bureau's citrate process for sulfur dioxide removal from stack gas. The plant was completed, and startup trials have been initiated. The company has budgeted $2.5 million to maintain compliance with regulations under the Environmental Protection Act. Historically Bunker Hill Co. has expended a grand total of $22 million on pollution control and related facilities.[31]

National Zinc Co., Inc., at Bartlesville, Okla., was under attack by the Oklahoma Air Pollution Board, but was granted a 1-year variance to secure financing for an $18 million plant addition to eliminate pollution.[32] The Federal deadline to comply with the pollution law or close down is July 1, 1975. The State of Oklahoma extended its variance until June 30, 1975.[33]

The company announced later that it will build a 50,000-ton-per-year electrolytic plant at Bartlesville to replace the 66-year-old horizontal retort smelter. The scheduled completion date was set for May 31, 1975.[34]

In the latter part of 1973, Engelhard Minerals & Chemicals Corp. contracted to purchase for $4 million the assets of National Zinc Co., Inc. Title to the properties at Bartlesville, Okla., was taken on February 11, 1974. The plan to erect an electrolytic zinc plant at the old site will hold firm. The new installation, estimated to cost approximately $30 million, should be onstream in early 1976, and the company hopes to continue operation of the retort furnaces until they are replaced by the new electrolytic process, but this will be subject to extension of the existing variances issued by pollution control authorities.[35]

Secondary Zinc Smelters.—Zinc recovered from zinc-bearing scrap was 387,539 tons in 1973, nearly the same as in 1972. Semimanufactured forms of zinc- and copper-base alloys accounted for 98% of the new and old scrap. New scrap, chiefly zinc- and copper-base alloys from manufacturers and drosses from galvanizing and die casting pots, accounted for 76% of all the scrap processed. Recovery of new scrap decreased, while old scrap increased to replace that which was not recovered in new scrap. The zinc was recovered in alloys, 53%, principally brass and bronze; in metal, 32%; and in chemical products, 15%.

Slag-Fuming Plants.—Slag-fuming plants process hot and cold lead blast furnace slags and residues which contain from 11% to 23% recoverable zinc to produce zinc oxide fume. The oxide is either sent to zinc smelters or electrolytic refineries for recovery of zinc, or sold to the consumers as zinc oxide. During the year three plants were operating: ASARCO at El Paso, Tex.,

[29] Page 31 of work cited in footnote 9.
[30] American Metal Market. N.J. Zinc Planning 160,000-Ton Smelter. V. 81, No. 133, July 10, 1974, p. 1.
[31] Page 7 of work cited in footnote 15.
[32] Tulsa Tribune. Pollution Agency Grants Extension. V. 79, No. 42, Feb. 21, 1973, p. 9B.
[33] Tulsa Tribune. Antipollution Controversy in Bartlesville is Dying Down. V. 79, No. 31, Feb. 8, 1973, p. 21A.
[34] Metals Week. National Zinc To Build Zinc Plant in Oklahoma. V. 45, No. 2, Jan. 14, 1974, p. 1.
[35] Engelhard Minerals & Chemicals Corp. 1973 Annual Report. P. 3.

and East Helena, Mont., and The Bunker Hill Co. at Kellogg, Idaho.

Byproduct Sulfuric Acid.—In 1973, there were nine plants with facilities for roasting zinc sulfide concentrates. Seven plants were equipped with sulfuric-acid-producing facilities, one of which operated solely for producing calcine for subsequent processing to zinc oxide or zinc metal. Two horizontal retort smelters did not have sulfuric-acid-producing facilities, one of these shut down its zinc smelter in November, but continued to operate the roaster. In 1973, production of byproduct sulfuric acid from the zinc plants and three lead smelters was 966,128 tons, compared with 859,103 tons produced in 1972.

Zinc Dust.—Production of zinc dust decreased 5% from that of 1972 to 56,154 tons in 1973. Zinc dust from distilled scrap accounted for 36,202 tons, 64% of the total zinc dust produced.

CONSUMPTION AND USES

Consumption of slab zinc in the United States in 1973 was 1,503,938 tons, an increase of 6% over that of 1972. The zinc content of the ore and concentrate used directly in galvanizing or to make pigments and salts was 129,651 tons (118,305 in 1972), and the zinc content of secondary materials to make alloys, zinc dust, and compounds totaled 298,336 tons (307,369 in 1972). Total consumption of zinc for all classes was 1,931,925 tons, an increase of 5% over that of 1972.

Slab zinc consumption was reported by 650 users in 1973. Of the total slab zinc consumed, zinc-base alloys accounted for 610,606 tons (41%); galvanizing, 563,837 tons (37%); brass products, 197,650 tons (13%); rolled zinc, 40,763 tons (3%); zinc oxide, 61,734 tons (4%); and other uses, 29,348 tons (2%). Most of the use categories showed gains over last year. The largest gain was in galvanizing, with an increase of 45,633 tons over that of 1972, followed by die casting alloys with a gain of 31,793 tons over 1972. A net gain of 85,589 tons was realized over last year. While gains were recorded for most of the use categories, losses were noted in slush and sand casting alloys, rolled zinc, and other uses.

Distribution of slab zinc consumed by grade in 1973 was as follows: Special High Grade, 739,447 tons (49%); High Grade, 167,466 (11%); Intermediate, 37,384 tons (3%); Brass Special, 132,148 tons (9%); Prime Western, 426,559 tons (28%); and Remelt, 934 tons (less than 0.1%). Compared with 1972, except for the small decline in Remelt, consumption of all grades of slab zinc increased. The largest increase was in Special High Grade with a gain of 41,866 tons.

Slab zinc consumed by rolling mills was 40,763 tons in 1973, a decrease of 10% from that of 1972. Production of rolled zinc products decreased 5% to 41,301 tons. Strip and foil accounted for 74%, and 20% was used for photoengraving plates. Exports were nearly unchanged from those of last year at 2,480 tons, while imports were cut in half from those of 1972. Nearly 30,000 tons of zinc was rolled from scrap in 1973; therefore, a total of 70,202 tons of rolled zinc was produced during the year, compared with 85,237 tons in 1972.

The leading slab-zinc-consuming States in 1973 were Ohio with 215,106 tons (14%); Pennsylvania, 201,168 tons (13%); Illinois, 195,382 tons (13%); Michigan, 163,602 tons (11%); Indiana, 149,651 tons (10%); and New York, 121,664 tons (8%). These leading six States accounted for almost 70% of the slab zinc consumed. Ohio ranked the highest for galvanizing with 108,241 tons, and Michigan was first in die casting with 140,465 tons.

ZINC PIGMENTS AND SALTS

Production.—Published data for zinc pigments and compounds include zinc oxide and zinc sulfate. Information for leaded zinc oxide, lithopone, and zinc chloride was withheld in 1971–73 to keep individual company data confidential.

Production of zinc oxide in 1973, 252,500 tons, increased 7% over 1972 production, and shipments were approximately equal to production. Zinc sulfate production, 43,900 tons, showed an increase, but the dry basis (100% $ZnSO_4$) was a smaller proportion of the gross weight than in former years.

The source of domestic zinc oxide production was 53% from ore and concentrate (American process), 32% from slab zinc (French process), and 15% from secondary material. Zinc sulfate production came 56%

from secondary material and 44% from ore or intermediate products. Lead-free zinc oxide was produced at 12 plants in the United States, and leaded zinc oxide was produced at only 1 plant. At least eight plants produced zinc sulfate, and five produced zinc chloride.

Production of zinc oxide by The New Jersey Zinc Co. and St. Joe Minerals Corp. were described under Smelter and Refinery Production. A third producer using ores or concentrates as a major source material was ASARCO with plants at Columbus, Ohio, and Hillsboro, Ill. Other major zinc oxide producers, such as the Eagle-Picher Industries, Inc., Hillsboro, Ill., plant and the Sherwin-Williams Coffeyville. Kans., plant, used calcines, fume, and secondary materials as raw materials.

Consumption and Uses.—The apparent consumption of zinc oxide increased by 5% from about 259,000 tons in 1972 to 273,000 tons in 1973. Analysis of domestic shipments by industry usage showed the rubber industry as consuming 51% of U.S. shipments, and reported destinations of imported oxide indicated a still higher percentage of imports going to rubber manufacturers. The second-ranking use was photocopying with a 7% annual increase, and third ranking was chemicals with a 15% annual increase. Use of zinc oxide in paints decreased slightly, probably owing to fewer housing starts in 1973. The use of zinc oxide in agriculture may have been partly concealed in "other" or "chemical" destinations. Agriculture is the chief use for zinc sulfate, with lesser amounts going for rayon, flotation reagents, and chemicals. The use of leaded zinc oxide in rubber and paints increased substantially during 1973, regaining the volume of several years ago. Zinc chloride usage declined slightly but continued to be a significant part of zinc compound consumption; incomplete industry returns precluded analysis of shipments by industry.

Prices.—Zinc oxide and compound prices tended to follow increases in the price of zinc metal, but the changes were often announced several days after the metal price change. At the beginning of 1973 prices ranged from 15.75 cents per pound for activation-grade zinc oxide through 18.75 cents for French process to 22 cents for U.S.P. grade. On January 29 price increases were initiated that averaged about 2 cents for each grade. On or about April 1 several companies posted further increases of 1 to 2 cents per pound. By June other suppliers had come up to a scale that ranged from 19 cents for activation grade through 22 cents for French process to 24 cents for U.S.P. grade. Prices remained steady during the period June 13 to December 6, when zinc prices were controlled by the Cost of Living Council. During the second week in December, after release from price control, three companies raised prices about 9 cents per pound so that at yearend most quotations ranged from 30.5 cents for American process lead-free pigment grade through 31.5 cents for French process to 33.5 cents for U.S.P. grade. Leaded zinc oxide was quoted at 17 cents per pound in January 1973 and had risen to 30.25 cents by January 1974. The price of zinc sulfate in June 1973 was reported as $13 per 100 pounds, granular monohydrate industrial, 36% zinc, bags in car-load lots. By yearend this price had become $18.50 per 100 pounds.

Foreign Trade.—Exports of zinc oxide increased by 24% during 1973 to a record 7,600 tons, and lithopone exports decreased by 29% to less than 1,000 tons. Imports of almost all classes of zinc compounds increased in 1973 to a total of 36,500 tons, a 40% gain. As in 1972, zinc oxide was the major component of imports of zinc compounds, with a 42% gain to 27,500 tons. The net imports of zinc oxide, 19,850 tons, thus became about 7% of U.S. supply. Mexico, Canada, and France were major sources, and other European Community countries contributed small tonnages.

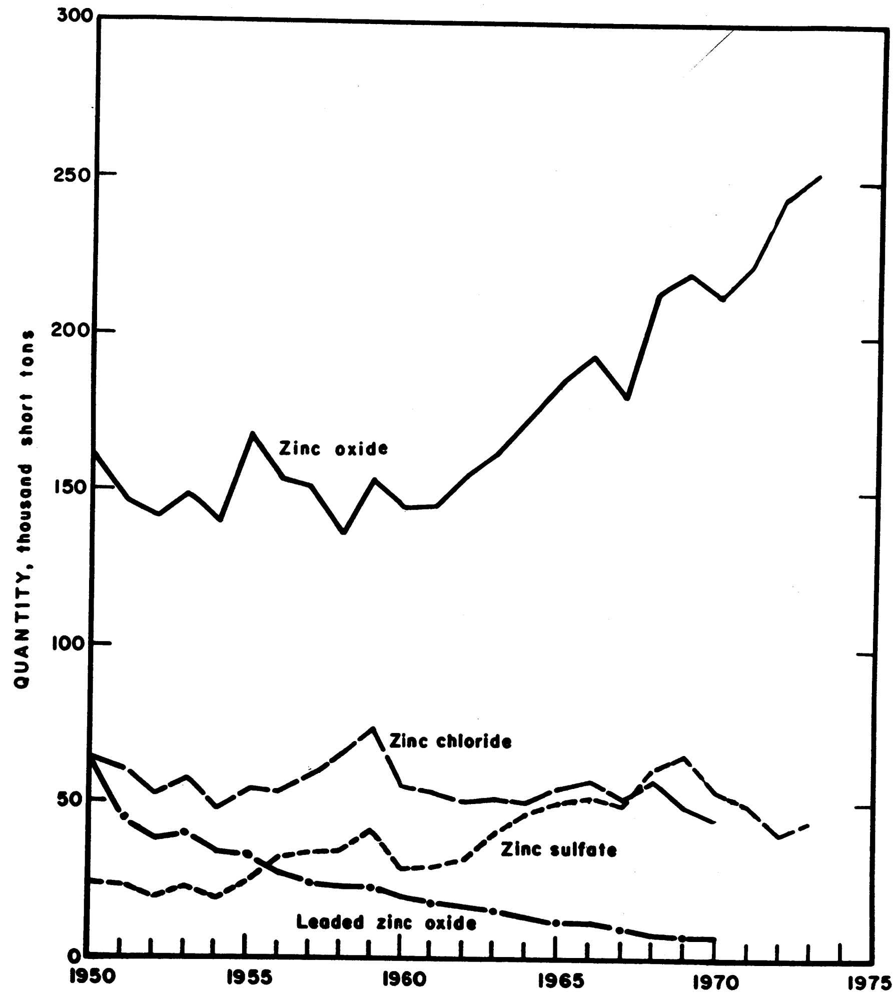

Figure 5.—Trends in shipments of zinc pigments.

STOCKS

Producer Stocks.—According to the monthly data reported by producers to the Zinc Institute, Inc., stocks at the beginning of the year were 31,775 tons. By midyear they declined to 22,168 tons, but at yearend they increased to 29,233 tons, just 2,542 tons short of what stocks were at the beginning of the year. The GSA stockpile gave considerable relief; 167,447 tons of zinc passed through the producers either as remelt or direct shipment.

Consumer Stocks.—Slab zinc inventories at consumer plants, which were 124,956 tons at the beginning of the year, declined 9% to 114,317 tons at yearend. Prime Western zinc stocks accounted for the largest decrease, 23% or 11,516 tons less than that at yearend 1972.

Government Stockpile.—During 1973, the GSA stockpile inventory was reduced from 949,583 tons to 677,583 tons. This indicates that 272,574 tons of slab zinc went into domestic supply from the Government stockpile.

PRICES

The year began with a three-tier price structure for domestic Prime Western zinc, 18.0, 18.5, and 18.52 cents per pound. Phase 3 of the President's economic stabilization program, effective January 11, 1973, removed the mandatory price ceiling on zinc, and by February 1, the price of Prime Western zinc was increased to 19.0, 19.25, and 19.5 cents per pound. On March 9, another round of price increases began, and by March 28, all the producers but one had increased their price of Prime Western zinc to 20.25 cents per pound. One company, National Zinc Co., Inc., increased its price to 20.5 cents per pound, and on April 19, this same company increased its price to 21 cents per pound while the other producers kept their price at 20.25 cents per pound. During all of this period, the price of Special High Grade zinc was 1 cent per pound higher than that of Prime Western zinc. On June 13, 1973, by Presidential order, the price of zinc was frozen to the last round of increases. Phase 4 of price controls became effective August 12, 1973, when the base price for zinc was set at the price during the last fiscal quarter prior to January 11, 1973, (18 cents per pound). Cost increases were passed through on a dollar-for-dollar basis without the maintenance of profit margins allowed under phases 2 and 3. The Cost of Living Council required a 30-day notice from producers with $100 million sales or more for any price increases. The ceiling prices prevailed until the Cost of Living Council abolished the control on zinc on December 6, 1973. One company immediately raised its price of Prime Western zinc to 32 cents per pound, and others quoted prices between 28 and 30 cents per pound where they remained to yearend.

The foreign producer price (mostly Canada, Peru, and Australia) was always at least 1 cent per pound higher than the U.S. producer price. Coming into the year, imported zinc (Prime Western equivalent) was 19.5 and 20 cents per pound. This price remained in effect until March 8, when the price became 21 cents per pound, but one company representing the Australian producers increased the price of zinc to 22.5 cents per pound on March 29 and to 23.5 cents per pound on May 29. Effective June 12, imported zinc (Prime Western equivalent) ranged from 22.3 to 23.5 cents per pound; however, one Canadian firm passed on the 0.7-cent-per-pound tariff to its U.S. customers. A second Canadian company followed suit on June 30, and a third company raised its price but absorbed the tariff. Effective August 1, 1973, imported zinc (Prime Western equivalent) ranged from 24.3 to 27.5 cents per pound. The high price of 27.5 cents per pound was set on July 26 by an Australian firm. On September 20, the spread increased to 24.3 to 31.0 cents per pound, but on October 1 the range narrowed to 27.3 to 31.0 cents per pound. The high side of the price range increased on November 27 to 36.5 cents per pound, and the final increase for the year on December 21, 1973, occurred on the low end of the range with a price of 31.0 cents per pound.

The European producer price for Good Ordinary Brand (GOB) zinc (Prime Western equivalent) was £173 per metric ton (18.5 cents per pound U.S. equivalent) at the first of the year. During the year the European producer price increased five times, as follows: February 28, £190 per metric ton; June 14, £205 per metric ton; July 16, £220 per metric ton; September 24, £250 per metric ton; and on November 27, £300 per metric ton. The last conversion to U.S. equivalent was 31.5 cents per pound and was the price that prevailed to the end of the year.

The London Metal Exchange (LME) price for zinc started the year at a lower level than the U.S. producer price and the European producer price. The monthly average price for zinc in January was 17.5 cents per pound, but during the year the price fluctuated upward until it reached a record high on December 4, 1973, of 99 cents per pound. The price then declined to 63 cents per pound at yearend.

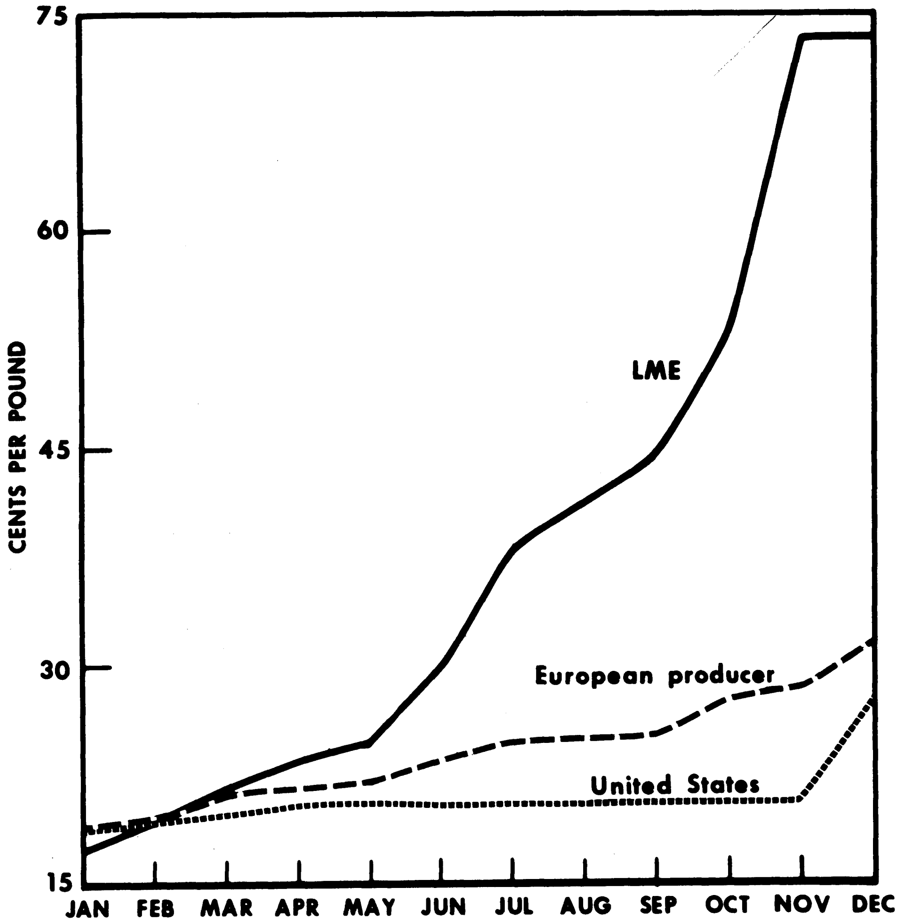

Figure 6.—Average monthly prices in 1973 for U.S. Prime Western zinc and equivalent foreign grade.

FOREIGN TRADE

Exports of slab zinc increased more than three-fold from 4,324 tons to 14,566 tons in 1973, of which 15% went to Brazil, 15% to Japan, 12% to Venezuela, and 11% to Colombia. Exports of rolled zinc products, sheets, plates, strips, etc., increased 3% over those of 1972; Canada received nearly half, 1,201 tons.

General imports of zinc in ore declined 22% to 199,053 tons in 1973, the lowest since 1940. Canada supplied 62%, or 124,261 tons, and receipts from Mexico accounted for 17%, or 33,878 tons. General imports of metal increased 13% to 588,725 tons. Canada with 344,697 tons, supplied 59%. The other large suppliers were Australia, Belgium-Luxembourg, Japan, and Zaire.

Imports of ore for consumption declined 12% to 153,898 tons in 1973. Since the imports of ores for consumption had been significantly less than general imports of ore for the last 2 years, this suggested that a buildup of ores was taking place at the bonded warehouses. Metal imports for consumption increased 14% over those of 1972 to 587,429 tons in 1973, and were only slightly less than general imports. This was the second year in a row in which imports of metal exceeded the quantity of zinc in imported ores and concentrates.

No change took place in the tariff rates in 1973. The duties on unmanufactured zinc and zinc-containing materials were as follows: Slab zinc, 0.7 cent per pound; zinc ores, concentrates, and fume, 0.67 cent per pound (on zinc content less specified allowable deductions for processing losses); zinc scrap, including skimmings and drosses, 0.75 cent per pound; and zinc dust, 0.3 cent per pound. The duty rate for unwrought alloys of zinc, which includes diecasting alloys, was 19% ad valorem.

The bill to suspend the U.S. tariff on zinc concentrates (H.R. 6191) passed the House on May 7, 1974, after which it was submitted to the Senate Finance Committee.

WORLD REVIEW

World mine production of zinc in 1973 gained about 3% over that of 1972, continuing the slow but steady growth rate apparent in recent years. Zinc metal production also increased, with gains in Europe and Canada more than making up for the loss of production in the United States. The consumption of zinc in the developing countries continued to grow at a faster rate (12%) than the world average (7%) and helped to maintain a worldwide shortage, driving up prices and spurring the use of substitute materials where available. The generally tight supply situation increased interest in secondary materials and concern for gathering information about their availability and use. Byproducts and scrap were used in greater amounts for production of both zinc metal and zinc compounds.

Argentina.—Compañía Minera Aguilar, a subsidiary of St. Joe Minerals Corp., sustained a 2-week strike in November which was settled after the national government intervened and negotiated a 20% wage increase. Production of zinc concentrates in 1973 was 9% less than in 1972 and was estimated to contain about 43,700 tons of zinc. Two zinc smelters affiliated with Aguilar but not affected by the strike produced about 40,900 tons of zinc in 1973.[36]

Australia.—Mine production of zinc in Australia declined 6% in 1973 to 526,400 short tons of zinc in concentrates. Exports to the United States included 7,281 tons of zinc in concentrates and 42,077 tons of slab zinc, 10% of Australian zinc production.

The decrease in national mine production was due in part to the failure of a stope wall in the New Broken Hill Consolidated Mines at about the No. 17 level during the first week in October. The temporary closure of haulage on the No. 15 level caused a shortfall in production at this most productive Australian zinc mine during the last quarter. Zinc Corp., North Broken Hill, Mount Isa Mines, West Coast Mines, and Cobar mines contributed a normal or slightly reduced zinc production during 1973. Broken Hill South, Ltd., recovered about 8,000 tons of zinc from dumps, partially replacing the loss of production from the closed Broken Hill South mine.

Published ore reserves and announced plans for expansion predicted greater zinc production from Australia in the future. Mount Isa Mines (MIM) was developing the Hilton mine, about 12 miles north of Mount Isa, and was increasing capacity at the Mount Isa concentrator. Both mines have large reserves of zinc-lead-silver ores, 36 million tons at Hilton and 56 million tons at Mount Isa.[37] MIM also holds large reserves or resources of zinc-lead ores in the McArthur River area, Northern Territory, estimated to contain 200 million tons assaying 9% zinc.[38] E–Z Industries, Ltd., planned to expand zinc capacity at its mines in Tasmania and its smelter at Risdon to a yearly production of 242,000 tons of zinc.

Smelter production in 1973 was 328,000 short tons of zinc: Risdon (E–Z Industries) 213,000, Cockle Creek (Conzinc Rio Tinto of Australia) 65,000, and Port Pirie (BHAS Proprietary, Ltd.) 50,000.

Belgium.—Zinc production increased 9% during 1973 to a total of 309,800 tons. Exports to the United States were about 39,400 tons of slab zinc. Metallurgie Hoboken-Overpelt was constructing a new elec-

[36] Lead and Zinc Statistics, Monthly Bulletin of the International Lead and Zinc Study Group. V. 14, No. 6, June 1974, pp. 16–17.

[37] M.I.M. Holdings Ltd. Annual Report for the Year Ending June 30, 1973. P. 7.

[38] Mount Isa Mines. Metals Sourcebook. No. 21, Oct. 29, 1973, p. 2.

trolytic zinc refinery at Overpelt scheduled for commissioning in mid-1974; the older zinc retorts were shut down progressively so that zinc production decreased in 1973 from the 1972 output. Société de Prayon, S.A. sustained its first full year of production at its new electrolytic plant at Ehein. Société des Mines et Fonderies de Zinc de la Viellie Montagne, with four plants in Belgium, produced a total of 281,000 tons of ingot zinc, 5% more than in 1972, but plants in France participated in this production.

Brazil.—The two electrolytic zinc plants in Brazil produced 24,600 tons of zinc in 1973, achieving a 43% increase from production in 1972. Both plants are supplied by the silicate and oxide ores from Vazante, Minas Gerais. The Companhia Minera de Metais, one of the two producers, has announced plans to increase production to about 29,000 tons annually by 1977, using a new process developed by Metais and a German firm, Lurgi Chemie und Huettentechnik.

Canada.—Mine production of zinc increased again in 1973 to 1.49 million short tons of zinc content in concentrates. Zinc smelter production increased to 587,000 tons in 1973, a 12% increase from the 525,000 tons in 1972. Canada thus retained by a wide margin its position as the world's largest zinc-mining country and passed the United States to become the third largest zinc-refining country. A substantial part of this production came to the United States. Of a total of 874,900 short tons of zinc in concentrates exported from Canada, 124,300 tons was imported into the United States; of 463,000 tons of metal exported, 345,000 tons came to the United States as general imports. Consumption of zinc in Canada was estimated as 140,000 tons, a 9% increase from 1972 consumption.

In the Northwest Territories, Pine Point Mines Ltd., with Cominco, Ltd., acting as operator, was the major zinc producer mining 3,896,000 tons of ore averaging 6.0% zinc and 2.9% lead. Concentrates from this operation were sold to Canadian refineries, chiefly Cominco, 62%. The remainder was exported with Europe receiving 20%, Japan, 10%, India, 5%, and South America and United States, collectively, 3%.[39] Cominco continued exploration of silver-zinc deposits near Bathurst Inlet and at the Polaris lead-zinc deposit on Little Cornwallis Island. Several thousand tons of high-grade ore (35% to 40% lead-zinc) was shipped from the Polaris mine for metallurgical testing. Texasgulf, Inc., has formed a joint venture with Mineral Resources International Ltd. to study and possibly develop a zinc-lead property on the north shore of Baffin Island. All three of these Arctic deposits will be hampered in their development by a short shipping season, and the logistics of their operations will require careful cost studies; but the high grade of the deposits insures their eventual exploitation.

The major zinc mine in Yukon Territory, Anvil Mining Corp. Ltd. at Faro, took 2,899,000 tons of ore from its open pit operation and produced concentrates containing 118,000 tons of zinc, 112,000 tons of lead, and 2,578,000 ounces of silver.[40] The Anvil concentrator capacity was increased from 8,000 to 10,000 tons daily during 1973. Anvil and other companies announced exploration programs in the Yukon Territory for 1974; Anvil planned a regional geochemical survey covering large areas of favorable carbonate rocks, and Barrier Reef Resources Ltd. arranged to have its new discovery 125 miles northeast of Mayo drilled by two coventurers in 1974.

British Columbia zinc production increased about 13% in 1973 with the Sullivan mine of Cominco, Ltd., as the major producer. Cominco resumed mining at the H.B. mine near Salmo; its output will replace the concentrates formerly drawn from the Bluebell mine, shut down in 1972. Other mines producing zinc in the province were the Bradina at Houston (suspended operations August 1973), the Silmonac at Sandon, the Reeves MacDonald at Remac, the Highland Bell at Beaverdell, and Western Mines at Buttle Lake. Reeves MacDonald Mines Ltd. announced that mining and milling at its properties would be discontinued on October 1, 1973; exploration has been unsuccessful in locating new reserves but would continue on adjoining properties. Exploration in the Province appeared to fall off during 1973, but Texasgulf continued its drilling program at the Robb Lake lead-zinc prospect and reported encouraging results.[41] Several railway extensions were planned to extend service to

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[39] Pine Point Mines Ltd. 1973 Annual Report. P. 3.

[40] Page 12 of work cited in footnote 19.

[41] Texasgulf. 3rd Quarter Report. Sept. 30, 1973, p. 6.

northern British Columbia and to make a link in southwest British Columbia bypassing the Fraser River Canyon; mineral traffic and the development of new mining areas were primary reasons for the proposed construction. The Cominco smelter at Trail produced 248,000 tons of zinc in 1973; operations were hampered in December by an electrical failure and fire in the roaster control room, but by yearend zinc output had returned to normal.

In Manitoba, Hudson Bay Mining & Smelting Co. Ltd. achieved an 8% increase in zinc production in 1973 to 82,882 tons, and began development work on the new Centennial mine. Nine operating mines in the Flin Flon area produced continuously during the year. Ore reserves in the Flin Flon district at yearend were 18,000,600 tons containing 3.1% copper, 2.9% zinc, 0.03 ounce of gold, and 0.5 ounce of silver per ton.[42] Sherritt Gordon Mines, Limited, continued to operate the Fox Lake copper-zinc mine and in May began production from the new copper-zinc Ruttan mine. Production of zinc in concentrates at the two mines was 7,060 tons at Fox Lake and 17,130 tons at Ruttan, making Sherritt Gordon a major zinc producer, in addition to its substantial copper production. Concentrates went to Hudson Bay at Flin Flon, to Mitsubishi Metal Corp. in Japan, and to a zinc plant in the United States.[43] Freeport Canadian Exploration Co., in a joint venture with Beth-Canada Mining Co., discovered a copper-zinc deposit near Reed Lake, Manitoba; a preliminary estimate of the tonnage and grade was given at 1 million tons with about 2% copper and 4% zinc. The two companies are subsidiaries of Freeport Minerals Co. and Bethlehem Steel Corp., respectively.

The largest zinc producer in Ontario was Ecstall Mining Ltd., a subsidiary of Texasgulf, Inc., with a production of about 295,000 tons of zinc in concentrates from the Kidd Creek mine and 107,100 tons of zinc metal from the nearby zinc plant at Hoyle. Annual capacity of the refinery was to be increased from 120,000 to 150,000 tons per year. Production from the open pit mine will be gradually replaced by underground mining within a few years. During 1973, the Canadian Development Corporation, a Crown Corp., acquired a large share of the stock of Texasgulf, Inc., through a public tender offer.

Other zinc mines active in Ontario were Mattagami Lake Mines Ltd., Mattabi mine averaging over 3,000 tons per day grading 11.36% zinc, 1.10% copper, 1.06% lead, and 5.30 ounces of silver per ton and Noranda Mines Limited, Geco mine producing 4,880 tons per day grading 4.53% zinc, 1.70% copper, and 1.63 ounces of silver per ton.[44] The construction of a 1,200 ton-per-day concentrator and mine was started in the Sturgeon Lake area by Sturgeon Lake Mines Ltd. and Falconbridge Nickel Mines Ltd. At Parham in southeastern Ontario the Long Lake mine, a small mine by modern standards, began operation in March, producing about 7,000 tons of crude ore per month with a 10-man crew running the mine and heavy media plant. The upgraded ore, 4,600 tons per month, is trucked to St. Joe Minerals Corp. at Balmat, N.Y. Lynx Canada Exploration Ltd. and Canadian Reynolds Metals Co. Ltd. share ownership of the mine.

Hudson Bay Mining & Smelting Co. Ltd. began construction of a new zinc oxide plant near Brampton, Ontario. The planned initial capacity was 60 tons, increasing ultimately to 100 tons per day; as production reached capacity, an older plant in Montreal operated by a subsidiary of Hudson Bay, Zochem Ltd., would be gradually closed down.

Mattagami Lake Mines, Ltd., continued to be a major zinc producer in Quebec, milling 1,387,000 tons of ore averaging 7.48% zinc, 0.57% copper and 0.84 ounce of silver per ton. The Orchan Mines mill treated 270,100 tons averaging 7.39% zinc and 0.97% copper from the Orchan mine and 180,130 tons averaging 3.33% zinc and 1.45% copper from the Garon Lake mine. Kerr Addison Mines continued to operate the Normetal Mine and the Joutel Mine, producing 12,500 tons and 13,100 tons of zinc in concentrates, respectively. The Lake Dufault division of Falconbridge Copper Ltd. produced 18,795 tons of zinc in concentrates as a coproduct of copper production from ore that averaged 3.65% copper and 4.41% zinc. Manitou Barvue Mines Ltd. reopened the Louvem silver-zinc mine and operated its mill at a rate of 20,000 tons per month through 1973.

The Sullivan Mining Group Ltd. closed

[42] Hudson Bay Mining & Smelting Co. Ltd. 1973 Annual Report. P. 13.
[43] Sherritt Gordon Mines Ltd. 1973 Annual Report. P. 4.
[44] Noranda Mines Limited. 1973 Annual Report. Pp. 10–15.

the Weldon mine in June 1973 but continued operations at the Cupra and D'Estrie divisions, both producing zinc concentrates from copper-zinc ores. Development of the Clinton Copper Mines property was started with joint control by Dome Mines, Ltd.; reserves contain minor amounts of zinc. Total production of the Sullivan Group for fiscal year 1972–73 was 9,115 tons of zinc.

Canadian Electrolytic Zinc Ltd., owned by Mattagami Lake Mines, Noranda, Orchan Mines, and Kerr-Addison, announced that its electrolytic zinc plant is to be expanded from the present capacity of 400 tons to 620 tons per day by 1975. The expansion will cost $30 million to $45 million and will increase yearly production capacity from 145,000 to 225,000 tons.

In New Brunswick, the Brunswick Mining & Smelting Corp. Ltd. continued to operate the No. 6 and No. 12 mines and the concentrator treated 3,288,000 tons of ore averaging 9.8% combined lead and zinc.[45] The conversion of the zinc-lead Imperial-type smelter at Belledune to a lead smelter was completed early in 1973 and zinc concentrates are now shipped overseas. During 1973, Amax Base Metal Group, operating the Heath Steele Mines, produced 1,078,000 tons of ore yielding 78,000 tons of zinc concentrate. An expansion program started in 1972 proceeded toward an eventual increase in mine-mill production of about one-third when completed in 1975.[46] The Sullivan Mining Group, Ltd., announced plans to resume its Nigadoo River Mines operations in the Bathurst district, subject to negotiating satisfactory smelter contracts.

Nova Scotia was the scene of exploration at a potential zinc-lead property in the Gays River district. The mining division of Imperial Oil Ltd. was drilling on the property of Cuvier Mines with three drill rigs testing zinc-lead mineralization in dolomitized limestone over a wide area. A large tonnage of ore was reported to average 2.75% lead and 3.39% zinc.

A deposit with a similar Appalachian-type environment at Daniel's Harbor in Newfoundland was the subject of a feasibility study by Newfoundland Zinc Mines, Ltd., a subsidiary of Teck Corp., with American Metal Climax, Inc. as a coventurer. A high-grade portion of the ore body was reported to contain 4,400,000 tons averaging 8.8% zinc.

The Buchans mine in Newfoundland, 50% controlled and managed by ASARCO, suffered from a 6-month strike during 1973 but managed to produce 11,500 tons of zinc in concentrates, less than half normal production.[47]

Canadian zinc smelter production in 1973 and announced plans for future capacity are summarized as follows:

Company	Production in 1973 (short tons)	Planned capacity 1974–75 (tons per year)
Canadian Electrolytic Zinc Ltd., Valleyfield, Quebec	148,800	225,000
Cominco, Ltd., Trail, British Columbia	248,000	305,000
Hudson Bay, Mining & Smelting Co., Ltd., Flin Flon, Manitoba	82,900	80,000
Ecstall Mining Ltd., Timmins, Ontario	107,100	150,000

Finland.—The electrolytic plant at Kokkola produced 89,200 short tons of zinc metal in 1973. The mines at Vihanti, Pyhasalmi and Metsamonttu produced concentrates containing 41,150, 18,348 and 3,899 tons of zinc respectively. The Keretti and Vuonos mines produced 713 and 477 tons, zinc content, as byproduct concentrates from copper ores.

France.—Production of slab zinc in France in 1973 was 284,184 tons, slightly less than in 1972.[48] Zinc consumption was estimated to be 320,000 tons with the difference made up from net imports and producers' stocks.

Germany, West.—Production of zinc in West Germany increased in 1973 to 435,433 short tons and includes secondary making maximum use of producing capacities. Five German lead-zinc mines contributed about one-third of the total zinc output. One of the five, the Randsbeck mine, was scheduled for shutdown on January 31, 1974. Consumption of zinc was 511,000 tons, with 37% going into galvanizing.

Honduras.—The El Mochito mine produced during 1973 21,681 tons of zinc and 272 tons of cadmium in zinc concentrates as well as substantial amounts of gold, silver, and lead in lead concentrates.[49] A joint venture between Rosario Resources Corp.

[45] Page 12 of work cited in footnote 44.
[46] Page 18 of work cited in footnote 4.
[47] Page 20 of work cited in footnote 10.
[48] Zinc Institute, Inc. 1973 Annual Review. P. 16.
[49] Rosario Resources Corp. 1973 Annual Report. P. 6.

and ASARCO was formed to drive an exploratory tunnel beneath the old Rosario mine.

India.—Although lead and zinc prospects are known throughout India and Government statistics claim large ore reserves, Indian zinc smelter production in 1973 was only one-third of its rated capacity and accounted for only 16% of its consumption with the balance made up from imports. Hindustan Zinc, Ltd., produced 2,200 tons and has a capacity for 19,800 tons per year, and Cominco Binani Zinc Ltd. produced 11,800 tons but has a capacity for 22,000 tons per year. Hindustan's Debari smelter was shut down for much of the year because of a breakdown of the melting furnace, and at Cominco Binani labor disputes put the plant out of action for 3 months. Hindustan Zinc announced plans to increase mine capacity in the Zawar area and to expand smelter capacity to 45,000 tons by 1978–79.

Ireland.—Tara Exploration and Development Co. Ltd. started to develop its potentially large mine at Navan, County Meath, in July 1973, with an inclined entry and a 1,000-foot vertical shaft. Commercial production of ores was scheduled to begin in late 1975. The development program proceeded despite a setback by an adverse judicial decision concerning ownership of the northern part of the proposed state mining lease containing about 10 million tons of ore. The balance of the ore body, now under development, was said to contain about 67 million tons grading 10.9% zinc and 2.6% lead. Near the end of 1973, an agreement was negotiated with Noranda Mines Limited under which Noranda would arrange a $6 million line of credit in return for warrants to purchase 100,000 shares of Tara and other considerations subject to Tara obtaining an acceptable state mining lease. As a result of this association, Tara, together with its controlling parent, Northgate Exploration Ltd., and Noranda, began a joint study as to the feasibility of constructing an electrolytic zinc reduction plant in Ireland.[50]

Two other major lead-zinc mines in Ireland continued production in 1973. The Tynagh mine of Irish Base Metals Ltd. in County Galway produced 16,500 short tons of zinc, 1,300 tons of copper, and 45,000 tons of lead in concentrates. The mine at Silvermines, County Tipperary, 75% owned by Mogul of Ireland Ltd., treated 917,400 tons of ore to produce concentrates containing 59,500 tons of zinc and 17,600 tons of lead.[51]

The Irish Government announced in September 1973 that the 20-year tax holiday on profits of base metal mines was to end. A new tax system, beginning April 1, 1974, will allow prospecting and depreciation deductions with special provisions for companies already in production and relief for marginal mines.

Italy.—Production of slab zinc in Italy reportedly increased from 171,800 tons in 1972 to 209,500 tons in 1973. This reflected the operation during 1973 of the new Imperial Smelting furnace by Ammi Sarda, S.p.a., at Porto Vesme, Sardinia. Italy is still a net importer of zinc, importing about 53,000 tons of metal in 1973.

Japan.—Japan once again achieved world record production with a total of 929,000 tons of zinc metal. Mine production supplied about 291,000 tons of zinc in concentrates. Consumption of zinc increased 14% to 834,800 tons in 1973, and demand for remelted zinc metal increased by 20% to 59,300 tons, making total slab zinc consumption about 894,100 tons.[52] Akita Zinc Co. Ltd. reported that the program to double capacity at its Iljima plant to 14,000 tons per month was expected to be completed in the summer of 1974 with full production at the end of the year. At the end of 1973, Mitsui Mining & Smelting Co. Ltd. was increasing the capacity of its Hikoshima refinery from 5,500 to 7,700 tons per month. However, all Japanese zinc producers predicted setbacks in scheduled zinc production in 1974 owing to power restrictions caused by the energy shortage.

Mexico.—Production of zinc from mines in 1973 continued at a rate about the same as in 1972, slightly over 299,000 short tons. Smelter output of primary metal was below that of 1972, 74,000 tons versus 87,500 tons. Exports of zinc concentrates and metal from Mexico to the United States decreased sharply in 1973 from exports in 1972. U.S. general imports of zinc from Mexico were about 33,900 tons of zinc in concentrates and 1,900 tons as slab zinc, compared with 57,300 tons of zinc in con-

[50] Tara Exploration and Development Co. Ltd. 1973 Annual Report. P. 5.
[51] International Mogul Mines Ltd. 1973 Annual Report. P. 4.
[52] Metals Week. Japan's Consumption of Zinc Increased. V. 45, No. 24, June 17, 1974, p. 6.

centrates and 8,400 tons of slab zinc in 1972.

Industrias Peñoles, S.A., inaugurated its new electrolytic zinc refinery at Torreón on October 30, 1973. The new plant was expected to produce 115,000 tons of zinc annually as well as 200,000 tons of sulfuric acid and 935 tons of cadmium. The feed to the plant will be mainly Mexican concentrates, thus cutting Mexican exports of zinc concentrates from about 300,000 tons (gross) to 100,000 tons per year and gaining about $58 million per year in foreign exchange.

Two feasibility studies concerning construction of zinc refineries in Mexico were undertaken during 1973, one conducted by Asarco Mexicana, S.A. and Dowa Mining Co. of Japan and the other by Zincamex, S.A. and Mitsui. The Asarco Mexicana-Dowa study indicated that the proposed smelter would require imports of zinc ores or concentrates from outside Mexico, and thereafter negotiations made little progress.

Netherlands.—Construction of the new electrolytic zinc plant at Budel was substantially completed in 1973, and full production was expected for the third quarter of 1974.[53] The older retort smelter was being gradually phased out. Production of primary zinc in the Netherlands in 1973 was about 33,600 short tons.

Nicaragua.—Neptune Mining Co., owned 51.8% by ASARCO and 36% by Rosario Resources, produced over 12,000 tons of zinc and 138 tons of cadmium in zinc concentrates from the Vesubio mine. Rosario acquired the Rosita copper mine and the Siuna gold mine and announced plans to do exploration work in adjacent areas for base metals as well as gold and silver.

Peru.—The Cerro de Pasco Corp. properties in Peru were expropriated by the Peruvian government effective January 1, 1974, after talks, carried on during the second half of 1973, concerning a partial takeover, were unsuccessful. However, operations were still under Cerro control throughout 1973 and resulted in a high level of zinc output. Refined zinc produced by the Cerro smelter was 73,959 short tons, and zinc concentrates and calcines produced for export amounted to 115,728 tons of zinc content.[54] Compañia Minerales Santander, Inc., a subsidiary of St. Joe Minerals Corp., produced 69,725 tons of zinc concentrates in 1973, slightly less than in 1972. The total production of Peruvian ores and concentrates for export contained 379,300 tons of zinc, which when added to metal, powder, and sulfate production gives a total zinc output of 456,000 tons. Of this, only about 13,000 tons of zinc in concentrates and 19,000 tons of zinc as metal came to the United States.

Poland.—Production of zinc in Poland was estimated to be 259,000 short tons in 1973, making Poland the largest source of zinc in Europe outside Soviet Russia. Metal production approached the target of the 1971–75 5-year plan, 260,000 tons per year. Poland could be self-sufficient in zinc concentrate production, but has been importing about 30,000 to 40,000 tons per year of concentrates from nonsocialist countries. Poland has traditionally sold zinc on the international market and in 1973 exported about 38,000 tons to Western countries in addition to about 56,000 tons to Communist countries, mainly Soviet Russia.

Spain.—The Cartagena plant of Española del Zinc planned a new electrozinc refinery that would increase capacity from 33,000 to 82,000 tons per year by the middle of 1975. Asturiana del Zinc S.A. prepared to increase capacity from 88,000 tons to 132,000 tons per year with a new roasting plant using the Lurgi-Vieille Montagne process; the new installations were scheduled for completion late in 1974. Spanish mines produced 193,000 tons of concentrates in 1973 containing 104,000 tons of zinc, and metal production from two plants was 117,900 tons of zinc.

Sweden, Norway, and Denmark.—Production of slab zinc in Norway was 88,700 short tons in 1973; mine production of zinc in Sweden was 126,400 tons and in Norway was 21,300 tons. The Black Angel mine in Greenland (Denmark) began production late in the year and reported a production of 50,800 tons with a planned annual production of 94,000 tons of zinc. Cominco, Ltd., was a 61.5% owner of Vestgron Mines Ltd. which operated the Black Angel mine through a Danish subsidiary, Greenex, A/S. The deposit was reported to contain 4,100,000 tons of 20% combined lead and zinc and 1 ounce of silver per ton.

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[53] Rio Tinto Zinc Corp. 1973 Annual Report and Accounts. P. 29.
[54] Cerro Corp. 1973 Annual Report. P. 17.

Yugoslavia.—Zinc metal production in Yugoslavia in 1973 was 60,820 short tons, an increase of 13% over that of 1972. Three plants were the major contributors, the electrolytic plant of Trepča at Zvecán, the electrolytic plant at Sabac-Zorka, and the new imperial furnace smelter at Zletovo (Titov Veles) which started production in the summer of 1973. The annual capacity of the Titov Veles smelter should eventually become 72,000 tons of zinc and 39,000 tons of lead, all destined for export. Two new lead and zinc concentrators at Kriva Feja and Leposavci in Serbia were completed in 1973. Concentrates will go to the Trepča smelter. The Trepča Enterprise was renovating or developing several mines in Serbia and one in Montenegro in a program to increase lead and zinc mine production. Yugoslavian mine production of zinc was estimated as 110,000 tons of zinc in concentrates in 1973.

TECHNOLOGY

Research at the Bureau of Mines Rolla Metallurgy Research Center was conducted to develop a workable means for separating and recovering zinc and lead from flue dusts, slags, and other metallurgical processing wastes. The project included construction and operation of a continuous system for the recovery of zinc and lead from electric furnace steelmaking dusts. An evaluation of other zinc-bearing waste such as lead blast furnace slag will also be made. Another project at Rolla was to develop low-cost hydrometallurgical processes for recovering zinc and elemental sulfur from sphalerite concentrate with minimum evolution of sulfur oxides, hydrogen sulfide, or other pollutants. A project on reduction of zinc sulfide with iron was underway at the Albany Metallurgy Research Center. The objective was to determine the practicability of winning zinc from sulfide concentrates by direct reduction with iron, thereby bypassing sulfurous gas formation. The Reno Metallurgy Research Center was conducting a research project to develop an aqueous chlorine or anodic oxidation leaching process for extracting metal values from lead-zinc sulfide concentrates, and to develop techniques for recovering metal values from leaching solution in a marketable form.

Results of several research investigations or studies were published by the Bureau of Mines and Geological Survey.[55]

Gulf & Western Industries, Inc., and Occidental Petroleum Corp. were engaged in a $10 million joint venture to perfect a practical zinc chloride rechargeable battery system that would power urban and recreational vehicles.[56]

The International Lead-Zinc Research Organization (ILZRO) sponsored numerous projects in 1973 to develop fundamental data on particular applications of zinc or zinc-containing materials. Progress reports of these projects are released annually by means of the ILZRO Research Digest.

Work during the year involved an ILZRO Prototype House which illustrates a variety of zinc applications, improvement of die-casting processes, galvanizing, alloy development, and plating.[57]

A comprehensive coverage of zinc-related investigations and an extensive review of current world literature on the uses of zinc and its products are contained in monthly issues of the 1973 Zinc Abstracts published by the Zinc Institute. Inc., 292 Madison Avenue, New York, N.Y. 10017, and provided free of charge.

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[55] Kelly, J.E., and H.M. Harris. Contact Angle of Zinc on Some Ceramic Materials and Metals. J. Testing and Evaluation, JTEVA, v. 2, No. 1, January 1974, pp. 40–43.
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Wedow, H., Jr., T.H. Kilsgard, A.V. Heyl, and R.B. Hall. Zinc. Ch. in United States Mineral Resources. U.S. Geol. Surv. Prof. Paper 820, 1973, pp. 697–711.
[56] Page 15 of work cited in footnote 9.
[57] Pages 1–27 of work cited in footnote 47.

Table 3.—Mine production of recoverable zinc in the United States, by State

(Short tons)

State	1969	1970	1971	1972	1973
Arizona	9,039	9,618	7,761	10,111	8,427
California	3,327	3,514	3,003	1,202	20
Colorado	53,715	56,694	61,181	63,801	58,339
Idaho	55,900	41,052	45,078	38,647	46,107
Illinois	13,765	16,797	12,706	11,378	5,250
Kansas	1,900	1,186	--	--	--
Kentucky	4,988	4,189	5,268	1,780	273
Maine	7,639	9,114	5,850	5,820	19,640
Missouri	41,099	50,721	48,215	61,923	82,350
Montana	6,143	1,457	361	12	73
Nevada	941	127	71	--	--
New Jersey	25,076	28,683	29,977	38,096	33,027
New Mexico	24,308	16,601	13,959	12,735	12,327
New York	58,728	58,577	63,420	60,749	81,455
Oklahoma	2,744	2,650	--	--	--
Pennsylvania	33,035	29,554	27,438	18,344	18,857
South Dakota	--	1	--	--	--
Tennessee	124,532	118,260	119,295	101,722	64,172
Utah	34,902	34,688	25,701	21,853	16,800
Virginia	18,704	18,063	16,829	16,789	16,683
Washington	9,738	11,956	5,782	6,483	6,378
Wisconsin	22,901	20,634	10,645	6,873	8,672
Other States	--	--	3	--	--
Total	553,124	534,136	502,543	478,318	478,850

Table 4.—Mine production of recoverable zinc in the United States, by month

(Short tons)

Month	1972	1973	Month	1972	1973
January	37,747	40,807	August	40,130	40,911
February	40,087	36,881	September	38,262	42,721
March	45,579	39,218	October	40,880	43,275
April	41,704	37,204	November	38,079	41,006
May	44,007	40,086	December	33,609	38,656
June	41,905	37,731			
July	36,329	40,354	Total	478,318	478,850

Table 5.—Production of zinc and lead in the United States in 1973, by State and class of ore, from old tailings, etc., in terms of recoverable metals

(Short tons)

State	Zinc ore			Lead ore			Zinc-lead ore		
	Gross weight (dry basis)	Zinc content	Lead content	Gross weight (dry basis)	Zinc content	Lead content	Gross weight (dry basis)	Zinc content	Lead content
Arizona	--	--	--	--	--	--	--	--	--
California	--	--	--	222	8	34	(1)	(1)	(1)
Colorado	224,942	21,313	2,600	692	--	5	471,903	25,520	14,752
Idaho	9,270	423	9	244,660	2,045	26,084	874,256	42,871	34,639
Illinois	(2)	(2)	(2)	--	--	--	--	--	--
Kentucky	--	--	--	--	--	--	--	--	--
Maine	230,172	19,640	204	--	--	--	--	--	--
Missouri	--	--	--	7,585,647	82,350	487,143	--	--	--
Montana	--	--	--	195	3	11	328	11	13
New Jersey	193,402	33,027	--	--	--	--	--	--	--
New Mexico	128,367	12,035	2,484	--	--	--	1,542	64	68
New York	1,093,838	81,455	2,304	--	--	--	--	--	--
Pennsylvania	382,511	18,857	--	--	--	--	--	--	--
Tennessee	2,134,789	59,570	--	--	--	--	--	--	--
Utah	--	--	--	--	--	--	188,311	16,800	13,733
Virginia	577,348	16,683	2,637	--	--	--	--	--	--
Washington	--	--	--	500	--	5	212,289	6,376	2,211
Wisconsin	379,014	8,672	844	--	--	--	--	--	--
Other States	--	--	--	12	--	6	--	--	--
Total	5,353,653	271,675	11,082	7,831,928	84,406	513,288	1,748,629	91,642	65,416
Percent of total zinc-lead	--	57	2	--	18	85	--	19	11

See footnotes at end of table.

Table 5.—Production of zinc and lead in the United States in 1973, by State and class of ore, from old tailings, etc., in terms of recoverable metals—Continued

(Short tons)

State	Copper-zinc, copper-lead and copper-zinc-lead ores			All other sources [3]			Total		
	Gross weight (dry basis)	Zinc content	Lead content	Gross weight (dry basis)	Zinc content	Lead content	Gross weight (dry basis)	Zinc content	Lead content
Arizona	93,284	8,407	192	61,571,820	20	571	61,665,104	8,427	763
California	--	--	--	[1] 5,257	[1] 12	[1] 10	5,479	20	44
Colorado	390,354	10,310	8,818	107,502	1,196	1,937	1,195,393	58,339	28,112
Idaho	--	--	--	312,459	768	1,012	1,440,645	46,107	61,744
Illinois	--	--	--	[2] 66,848	[2] 5,250	[2] 541	66,848	5,250	541
Kentucky	--	--	--	--	273	--	--	273	--
Maine	--	--	--	--	--	--	230,172	19,640	204
Missouri	--	--	--	--	--	--	7,585,647	82,350	487,143
Montana	--	--	--	25,686	59	152	26,209	73	176
New Jersey	--	--	--	--	--	--	193,402	33,027	--
New Mexico	--	--	--	2,803,668	228	4	2,933,577	12,327	2,556
New York	--	--	--	--	--	--	1,093,838	81,455	2,304
Pennsylvania	--	--	--	--	--	--	382,511	18,857	--
Tennessee	1,322,930	4,602	--	--	--	--	3,457,719	64,172	--
Utah	--	--	--	--	--	--	188,311	16,800	13,733
Virginia	--	--	--	--	--	--	577,348	16,683	2,637
Washington	--	--	--	61,372	2	1	274,161	6,378	2,217
Wisconsin	--	--	--	--	--	--	379,014	8,672	844
Other States	--	--	--	--	--	--	12	--	6
Total	1,806,568	23,319	9,010	64,954,612	7,808	4,228	81,695,390	478,850	603,024
Percent of total zinc-lead	--	5	1	--	1	1	--	100	100

[1] Zinc-lead ore, and ore from "other sources" combined to avoid disclosing individual company confidential data.

[2] Zinc ore and ore from "other sources" combined to avoid disclosing individual company confidential data.

[3] Lead and zinc recovered from copper, gold, silver, and fluorspar ores, and from mill tailings and miscellaneous cleanups.

Table 6.—Twenty-five leading zinc-producing mines in the United States in 1973, in order of output

Rank	Mine	County and State	Operator	Source of zinc
1	Balmat	St. Lawrence, N.Y	St. Joe Minerals Corp	Zinc ore.
2	Buick	Iron, Mo	AMAX Lead Co. of Mo	Lead ore.
3	Sterling	Sussex, N.J	New Jersey Zinc Co	Zinc ore.
4	Bunker Hill	Shoshone, Idaho	Bunker Hill Co	Lead-zinc ore.
5	Eagle	Eagle, Colo	New Jersey Zinc Co	Zinc ore.
6	Zinc Mine Works	Jefferson, Tenn	U.S. Steel Corp	Do.
7	Blue Hill	Hancock, Maine	Kerramerican Inc	Do.
8	Friedensville	LeHigh, Pa	New Jersey Zinc Co	Do.
9	New Market	Jefferson, Tenn	American Smelting and Refining Company.	Do.
10	Burgin	Utah, Utah	Kennecott Copper Corp	Lead-zinc ore.
11	Austinville and Ivanhoe	Wythe, Va	New Jersey Zinc Co	Zinc ore.
12	Star Unit	Shoshone, Idaho	Bunker Hill Co. and Hecla Mining Co.	Lead-zinc ore.
13	Leadville	Lake, Colo	American Smelting and Refining Company.	Do.
14	Ground Hog	Grant, N. Mex	do	Do.
15	Jefferson City	Jefferson, Tenn	New Jersey Zinc Co	Zinc ore.
16	Edwards	St. Lawrence, N.Y	St. Joe Minerals Corp	Do.
17	Shullsburg	Lafayette, Wisc	Eagle-Picher Industries, Inc	Do.
18	Idarado	San Miguel, Colo	Idarado Mining Co	Copper-lead-zinc ore.
19	Bruce	Yavapai, Ariz	Cyprus Mines Corp	Copper-zinc ore.
20	Sunnyside	San Juan, Colo	Standard Metals Corp	Lead-zinc ore.
21	Pend Oreille	Pend Oreille, Wash	Pend Oreille Mines & Metals Co.	Do.
22	Ozark	Reynolds, Mo	Ozark Lead Co	Lead ore.
23	Young	Jefferson, Tenn	American Smelting and Refining Company.	Zinc ore.
24	Magmont	Iron, Mo	Cominco American Inc	Lead ore.
25	Viburnum #29	Washington, Mo	St. Joe Minerals Corp	Do.

Table 7.—Primary and redistilled secondary slab zinc produced in the United States[1]

(Short tons)

	1969	1970	1971	1972	1973
Primary:					
From domestic ores	458,754	403,953	403,750	400,969	365,307
From foreign ores	581,843	473,858	362,683	232,211	176,012
Total	1,040,597	877,811	766,433	633,180	541,319
Redistilled secondary	70,553	77,156	80,923	73,718	87,466
Total (excludes zinc recovered by remelting)	1,111,150	954,967	847,356	706,898	628,785

[1] Excludes processed GSA stockpile zinc.

Table 8.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by method of reduction

(Short tons)

Method of reduction	1969	1970	1971	1972	1973
Electrolytic primary	453,539	393,280	321,517	259,816	210,468
Distilled	587,058	484,531	444,916	373,364	330,851
Redistilled secondary:					
At primary smelters	60,607	65,776	68,612	63,034	64,485
At secondary smelters	9,946	11,380	12,311	10,684	22,981
Total	1,111,150	954,967	847,356	706,898	628,785

Table 9.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by grade

(Short tons)

Grade	1969	1970	1971	1972	1973
Special high	468,792	401,273	367,609	310,074	251,406
High	136,416	109,025	73,314	44,782	25,900
Intermediate	57,180	52,480	58,240	43,353	38,239
Brass special	89,306	71,811	71,100	76,954	60,034
Prime western	359,456	320,378	277,093	231,735	253,206
Total	1,111,150	954,967	847,356	706,898	628,785

Table 10.—Primary slab zinc produced in the United States, by State where smelted

(Short tons)

State	1969	1970	1971	1972	1973
Idaho	105,700	95,637	94,012	101,743	98,321
Illinois	131,243	110,835	46,389	--	25,163
Montana	174,034	148,697	115,480	69,754	--
Oklahoma	143,575	124,811	126,908	114,162	76,823
Pennsylvania[1]	286,164	222,096	228,651	210,860	199,224
Texas	199,881	175,735	154,993	136,661	141,788
Total	1,040,597	877,811	766,433	633,180	541,319

[1] Prior to 1972, included West Virginia.

Table 11.—Primary slab zinc plants by group capacity in the United States in 1973

Type of plant	Plant location	Slab zinc capacity (short tons)
Electrolytic plants:		
Amax Zinc Co., Inc	Sauget, Ill	279,000
American Smelting and Refining Company	Corpus Christi, Tex	
Bunker Hill Co	Kellogg, Idaho	
Horizontal-retort plants:		
American Smelting and Refining Company	Amarillo, Tex	470,500
Blackwell Zinc Co., American Metal Climax, Inc.[1]	Blackwell, Okla	
National Zinc Co	Bartlesville, Okla	
Vertical-retort plants:		
New Jersey Zinc Co	Palmertown, Pa	
St. Joe Minerals Corp	Josephtown, Pa	

[1] Zinc operations ended November 1973.

Table 12.—Secondary slab zinc plants, by group capacity in the United States in 1973

Company	Plant location	Slab zinc capacity (short tons)
W. J. Bullock, Inc	Fairfield, Ala	40,100
Gulf Reduction Co	Houston, Tex	
Hugo-Neu-Proler Co	Terminal Island, Calif	
Pacific Smelting Co	Torrance, Calif	
Prolerized-Shibo-Neu Co	Jersey City, N.J	

Table 13.—Stocks and consumption of new and old zinc scrap in the United States in 1973

(Short tons, gross weight)

Class of consumer and type of scrap	Stocks Jan. 1 [1]	Receipts	Consumption: New scrap	Consumption: Old scrap	Consumption: Total	Stocks Dec. 31
Smelters and distillers:						
New clippings	63	696	708	--	708	51
Old zinc	474	5,688	--	5,659	5,659	503
Engravers' plates	248	1,755	--	1,853	1,853	150
Skimmings and ashes	7,482	63,180	64,657	--	64,657	6,005
Sal skimmings	70	261	--	--	--	331
Die-cast skimmings	2,125	7,243	6,830	--	6,830	2,538
Galvanizers' dross	16,620	59,809	63,531	--	63,531	12,898
Diecastings	2,128	40,088	--	38,698	38,698	3,518
Rod and die scrap	107	1,935	--	2,011	2,011	31
Flue dust	1,430	4,033	4,705	--	4,705	758
Chemical residues	--	15,320	15,320	--	15,320	--
Total	30,747	200,008	155,751	48,221	203,972	26,783
Chemical plant, foundries, and other manufacturers:						
New clippings	2	21	21	--	21	2
Old zinc	1	12	--	4	4	9
Engravers' plates	--	--	--	--	--	--
Skimmings and ashes	4,670	10,313	12,397	--	12,397	2,586
Sal skimmings	6,942	4,645	6,256	--	6,256	5,331
Die-cast skimmings	--	--	--	--	--	--
Galvanizers' dross	--	--	--	--	--	--
Diecastings	37	140	--	156	156	21
Rod and die scrap	4	65	--	66	66	3
Flue dust	230	4,445	4,425	--	4,425	250
Chemical residues	496	28,289	27,822	--	27,822	963
Total	12,382	47,930	50,921	226	51,147	9,165
All classes of consumers:						
New clippings	65	717	729	--	729	53
Old zinc	475	5,700	--	5,663	5,663	512
Engravers' plates	248	1,755	--	1,853	1,853	150
Skimmings and ashes	12,152	73,493	77,054	--	77,054	8,591
Sal skimmings	7,012	4,906	6,256	--	6,256	5,662
Die-cast skimmings	2,125	7,243	6,830	--	6,830	2,538
Galvanizers' dross	16,620	59,809	63,531	--	63,531	12,898
Diecastings	2,165	40,228	--	38,854	38,854	3,539
Rod and die scrap	111	2,000	--	2,077	2,077	34
Flue dust	1,660	8,478	9,130	--	9,130	1,008
Chemical residues	496	43,609	43,142	--	43,142	963
Total	43,129	247,938	206,672	48,447	255,119	35,948

[1] Figures partly revised.

Table 14.—Production of zinc products from zinc-base scrap in the United States

(Short tons)

Products	1969	1970	1971	1972	1973
Redistilled slab zinc	70,553	77,156	80,923	r 73,718	87,466
Zinc dust	33,747	29,605	29,095	40,569	36,531
Remelt zinc	3,978	3,494	1,590	5,850	1,096
Remelt die-cast slab	16,979	16,686	18,339	13,555	12,595
Zinc-die diecasting alloys	4,401	4,361	3,316	3,927	4,786
Galvanizing stocks	1,849	762	633	872	670
Secondary zinc in chemical products	45,298	42,238	45,312	50,047	56,591

r Revised.

Table 15.—Zinc recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1972	1973	Form of recovery	1972	1973
New scrap:			As metal:		
Zinc-base	145,620	137,671	By distillation:		
Copper-base	158,834	152,190	Slab zinc [1]	r 73,718	87,466
Aluminum-base	3,649	4,035	Zinc dust	40,123	36,202
Magnesium-base	281	306	By remelting	6,674	1,737
Total	308,384	294,202	Total	r 120,515	125,405
Old scrap:			In zinc-base alloys	16,480	16,362
Zinc-base	42,998	50,301	In brass and bronze	r 192,647	180,674
Copper-base	32,456	38,494	In aluminum-base alloys	7,638	7,961
Aluminum-base	3,854	4,436	In magnesium-base alloys	434	546
Magnesium-base	69	106	In chemical products:		
Total	79,377	93,337	Zinc oxide (lead-free)	25,897	29,289
			Zinc sulfate	11,076	9,444
Grand total	387,761	387,539	Zinc chloride	11,126	16,639
			Miscellaneous	1,948	1,219
			Total	r 267,246	262,134
			Grand total	387,761	387,539

r Revised.
[1] Includes zinc content of redistilled slab made from remelt die-cast slab.

Table 16.—Zinc dust produced in the United States

Year	Quantity (short tons)	Value	
		Total (thousands)	Average per pound
1969	55,055	$21,361	$0.194
1970	51,136	20,045	.196
1971	50,259	19,691	.196
1972	59,358	24,669	.208
1973	56,154	29,279	.261

Table 17.—Consumption of zinc in the United States

(Short tons)

	1969	1970	1971	1972	1973
Slab zinc	1,385,380	1,186,951	1,254,059	1,418,349	1,503,938
Ores (recoverable zinc content) [1]	126,712	124,781	119,254	118,305	129,651
Secondary (recoverable zinc content) [2]	302,075	259,864	277,381	r 307,369	298,336
Total	1,814,167	1,571,596	1,650,694	r 1,844,023	1,931,925

r Revised.
[1] Includes ore used directly in galvanizing.
[2] Excludes redistilled slab and remelt zinc.

Table 18.—Slab zinc consumption in the United States, by industry use

(Short tons)

Industry and product	1969	1970	1971	1972	1973
Galvanizing:					
Sheet and strip	268,682	253,155	255,335	294,205	321,927
Wire and wire rope	32,348	30,857	29,895	30,769	34,315
Tubes and pipe	65,898	64,479	65,122	64,549	68,048
Fittings (for tube and pipe)	11,418	9,498	10,240	11,106	11,969
Tanks and containers	5,561	3,924	2,759	3,645	2,941
Structural shapes	19,454	18,761	18,589	20,302	21,714
Fasteners	5,536	5,318	5,159	4,310	4,782
Pole-line hardware	9,409	9,938	8,358	8,437	8,193
Fencing, wire, cloth, and netting	17,984	18,114	20,232	21,995	25,418
Other and unspecified uses	57,091	60,205	59,063	58,886	64,530
Total	493,381	474,249	474,752	518,204	563,837
Brass products:					
Sheet, strip, and plate	90,777	61,672	78,929	105,405	109,582
Rod and wire	56,989	41,459	46,514	63,143	63,164
Tube	10,928	9,086	9,399	8,886	10,858
Castings and billets	5,958	4,606	4,479	6,840	6,000
Copper-base ingots	13,642	9,946	10,440	7,137	6,895
Other copper-base products	1,175	978	725	736	1,151
Total	179,469	127,747	150,486	192,147	197,650
Zinc-base alloy:					
Diecasting alloys	565,839	453,490	504,823	566,932	598,725
Dies and rod alloy	504	87	270	56	111
Slush and sand-casting alloy	10,048	10,059	11,018	12,773	11,770
Total	576,391	463,636	516,111	579,761	610,606
Rolled zinc	48,650	41,065	38,852	45,216	40,763
Zinc oxide	41,447	43,829	40,043	51,992	61,734
Other uses:					
Light-metal alloys	7,562	3,985	4,575	6,300	7,466
Other [1]	38,480	32,440	29,240	24,729	21,882
Total	46,042	36,425	33,815	31,029	29,348
Grand total	1,385,380	1,186,951	1,254,059	1,418,349	1,503,938

[1] Includes zinc used in making zinc dust, wet batteries, desilverizing lead, bronze powder, alloys, chemicals, castings, and miscellaneous uses not elsewhere mentioned.

Table 19.—Slab zinc consumption in the United States in 1973, by grade and industry use

(Short tons)

Industry	Special high grade	High grade	Inter-mediate	Brass special	Prime [1] western	Remelt	Total
Galvanizing	40,242	31,745	16,235	125,083	350,054	478	563,837
Brass and bronze	43,745	113,421	86	6,795	33,568	35	197,650
Zinc-base alloy	595,867	13,739	14	269	388	329	610,606
Rolled zinc	16,553	479	20,462	--	3,269	--	40,763
Zinc oxide	25,930	2,876	195	--	32,733	--	61,734
Other	17,110	5,206	392	1	6,547	92	29,348
Total	739,447	167,466	37,384	132,148	426,559	934	1,503,938

[1] Includes select grade.

Table 20.—Rolled zinc produced and quantity available for consumption in the United States

	1972			1973		
	Short tons	Value: Total (thousands)	Value: Average per pound	Short tons	Value: Total (thousands)	Value: Average per pound
Production:[1]						
Photoengraving plate	13,418	$10,118	$0.377	8,379	$6,401	$0.382
Sheet zinc less than 0.375 inch thick	--	--	--	--	--	--
Strip and foil	28,189	17,100	.303	30,362	19,869	.327
Total rolled zinc[2]	r 43,473	28,820	r.332	41,301	28,524	.345
Exports	2,419	2,138	.442	2,480	2,100	.423
Imports	485	310	.320	236	159	.339
Available for consumption	r 41,314	--	--	37,801	--	--

r Revised.

[1] Figures represent net production. In addition, 41,764 tons in 1972 and 28,901 tons in 1973 were rerolled from scrap originating in fabricating plants operating in connection with zinc-rolling mills.

[2] Includes other plate over 0.375 inch thick, and rod and wire; Bureau of Mines not at liberty to publish these data separately.

Table 21.—Slab zinc consumption in the United States in 1973, by industry and State

(Short tons)

State	Galvanizers	Brass mills[1]	Die-casters[2]	Other[3]	Total
Alabama	51,320	W	--	W	53,445
Arizona	W	--	--	W	W
Arkansas	--	--	--	W	W
California	38,269	3,032	17,018	2,541	60,860
Colorado	W	W	W	W	4,200
Connecticut	3,647	42,172	W	W	49,996
Delaware	W	W	W	--	W
Florida	W	--	W	--	5,332
Georgia	W	--	W	--	W
Hawaii	W	--	--	--	W
Idaho	--	--	W	W	W
Illinois	54,753	27,431	100,634	12,564	195,382
Indiana	62,295	W	W	W	149,651
Iowa	W	--	--	W	1,280
Kansas	--	W	W	--	W
Kentucky	W	W	W	W	W
Louisiana	1,758	--	W	W	1,900
Maine	W	--	--	--	W
Maryland	27,389	--	--	--	27,389
Massachusetts	2,530	W	--	W	6,100
Michigan	5,681	W	140,465	W	163,602
Minnesota	2,841	--	--	--	2,841
Mississippi	W	--	--	--	W
Missouri	8,018	W	W	W	14,500
Nebraska	W	W	--	W	4,256
New Jersey	2,026	6,672	W	W	17,133
New York	14,356	W	81,163	W	121,664
North Carolina	--	--	W	W	W
Ohio	108,241	W	94,988	W	215,106
Oklahoma	8,013	--	W	W	15,624
Oregon	1,060	W	W	W	2,727
Pennsylvania	83,334	W	35,043	W	201,168
Rhode Island	W	--	--	W	W
South Carolina	W	--	--	--	W
Tennessee	W	--	W	W	W
Texas	13,721	W	W	W	50,088
Utah	W	W	--	--	W
Virginia	W	W	W	W	269
Washington	919	--	--	2,049	2,968
West Virginia	W	W	W	W	33,151
Wisconsin	1,275	W	12,544	W	17,926
Undistributed	71,913	118,308	128,422	114,599	84,446
Total[4]	563,359	197,615	610,277	131,753	1,503,004

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Includes brass mills, brass ingot makers, and brass foundries.

[2] Includes producers of zinc-base alloy for diecastings, stamping dies, and rods.

[3] Includes slab zinc used in rolled zinc products and in zinc oxide.

[4] Excludes remelt zinc.

Table 22.—Production and shipments of zinc pigments and compounds[1] in the United States

Pigment or compound	1972 Production (short tons)	1972 Shipments Quantity (short tons)	1972 Shipments Value[2] Total (thousands)	1972 Shipments Value[2] Average per ton	1973 Production (short tons)	1973 Shipments Quantity (short tons)	1973 Shipments Value[2] Total (thousands)	1973 Shipments Value[2] Average per ton
Zinc oxide[3] ----	237,015	245,867	$84,244	$343	252,475	252,833	$88,378	$350
Zinc sulfate ----	38,897	39,595	5,220	132	43,866	45,197	5,510	122

[1] Excludes leaded zinc oxide, lithopone, and zinc chloride; figures withheld to avoid disclosing individual company confidential data.
[2] Value at plant, exclusive of container.
[3] Zinc oxide containing 5% or more lead is classed as leaded zinc oxide.

Table 23.—Zinc content of zinc pigments[1] and compounds produced by domestic manufacturers, by source

(Short tons)

Pigment or compound	1972 Zinc in pigments and compounds produced from— Ore	1972 Slab zinc	1972 Secondary material	1972 Total zinc in pigments and compounds	1973 Zinc in pigments and compounds produced from— Ore	1973 Slab zinc	1973 Secondary material	1973 Total zinc in pigments and compounds
Zinc oxide -----	109,133	52,117	31,106	192,356	112,638	67,457	31,821	211,916
Zinc sulfate ---	5,113	--	8,280	13,393	6,339	--	8,226	14,565

[1] Excludes leaded zinc oxide, zinc sulfide, and lithopone; figures withheld to avoid disclosing individual company confidential data.

Table 24.—Distribution of zinc oxide shipments, by industry[1]

(Short tons)

Industry	1969	1970	1971	1972	1973
Rubber	115,988	111,421	124,472	129,170	129,462
Paints	25,170	21,894	24,990	27,244	26,115
Ceramics	9,469	9,011	8,125	10,702	11,678
Chemicals	22,775	19,435	18,901	22,781	26,187
Agriculture	4,007	2,246	1,615	1,101	2,044
Photocopying	27,566	31,850	34,504	36,190	38,724
Other	14,748	17,426	14,896	18,679	18,623
Total	219,723	213,283	227,503	245,867	252,833

[1] For information on leaded zinc oxide shipments prior to 1971, refer to the 1970 Minerals Yearbook.

Table 25.—Distribution of zinc sulfate shipments, by industry

(Short tons)

Year	Agriculture Gross weight	Agriculture Dry basis	Other[1] Gross weight	Other[1] Dry basis	Total Gross weight	Total Dry basis
1969	19,029	16,424	45,563	33,861	64,592	50,285
1970	17,213	14,803	36,856	26,572	54,069	41,375
1971	16,268	13,812	33,035	28,690	49,303	42,502
1972	10,496	8,602	29,099	25,935	39,595	34,537
1973	13,909	8,353	31,288	24,902	45,197	33,255

[1] Includes rayon; Bureau of Mines not at liberty to publish these data separately.

Table 26.—Stocks of slab zinc at zinc-reduction plants in the United States, December 31

(Short tons)

Stocks	1969	1970	1971	1972	1973
At primary reduction plants	64,903	97,576	40,745	19,956	19,574
At secondary distilling plants	885	738	475	1,225	717
Total	65,788	98,314	41,220	21,181	20,291

Table 27.—Consumers stocks of slab zinc at plants, December 31, by grade

(Short tons)

Date	Special high grade	High grade	Inter-mediate	Brass special	Prime western	Remelt	Total
Dec. 31, 1972 [r]	46,696	9,552	570	17,267	50,776	95	124,956
Dec. 31, 1973	47,775	9,703	2,296	14,314	39,260	969	114,317

[r] Revised.

Table 28.—Average monthly U.S., LME, and European producers' prices for Prime Western Zinc and equivalent

(Metallic zinc, cents per pound)

Month	1972			1973		
	United States	LME [1] cash	European producer	United States	LME [1] cash	European producer
January	17.00	17.21	17.49	18.66	17.53	18.49
February	17.00	17.66	17.71	19.28	19.12	19.05
March	17.30	17.99	17.81	19.85	21.50	21.31
April	17.74	17.90	17.76	20.32	23.25	21.41
May	17.88	17.51	17.78	20.39	24.88	21.81
June	18.00	16.77	17.48	20.31	29.71	23.45
July	18.00	16.49	17.75	20.34	38.09	24.58
August	18.00	16.48	17.78	20.34	41.43	24.71
September	18.00	16.69	17.72	20.31	44.20	25.00
October	18.00	16.48	17.38	20.37	52.65	27.55
November	18.00	17.16	17.31	20.35	73.31	28.42
December	18.11	17.00	18.40	27.37	73.29	31.54
Average for year	17.75	17.13	17.73	20.66	38.55	24.00

[1] London Metal Exchange.

Source: Metals Week.

Table 29.—U.S. exports of slab and sheet zinc, by country

Destination	1971 Quantity (short tons)	1971 Value (thousands)	1972 Quantity (short tons)	1972 Value (thousands)	1973 Quantity (short tons)	1973 Value (thousands)
Slabs, pigs, blocks:						
Belgium-Luxembourg	--	--	--	--	221	$89
Brazil	1	$1	1	$1	2,123	1,492
Canada	233	63	349	70	509	101
Chile	8	3	10	5	459	608
Colombia	--	--	--	--	1,651	891
Costa Rica	--	--	--	--	607	188
El Salvador	--	--	--	--	528	277
Guatemala	--	--	--	--	220	87
Italy	--	--	--	--	110	44
Japan	--	--	--	--	2,151	1,325
Laos	--	--	--	--	110	95
Malaysia	--	--	--	--	108	75
Netherlands	--	--	--	--	1,488	610
Panama	--	--	3	2	209	85
Philippines	--	--	--	--	769	458
Switzerland	--	--	--	--	964	328
Turkey	3,024	738	--	--	--	--
United Kingdom	10,005	1,501	3,786	568	110	109
Venezuela	--	--	110	42	1,817	1,138
Other	75	31	65	26	412	259
Total	13,346	2,337	4,324	714	14,566	8,259
Sheets, plates, strips, or other forms, n.e.c.:						
Algeria	--	--	--	--	22	23
Argentina	51	34	32	23	28	21
Australia	85	75	51	42	24	23
Canada	1,065	946	1,329	1,194	1,201	986
Chile	2	2	23	16	26	21
Colombia	4	4	7	5	24	26
Costa Rica	14	13	12	11	11	11
Dominican Republic	51	20	15	12	21	17
Ecuador	8	8	8	8	27	29
Egypt	--	--	--	--	36	25
El Salvador	14	13	10	10	15	14
France	(1)	(1)	33	39	49	61
Hong Kong	1	4	6	5	49	38
Ireland	16	17	20	23	--	--
Israel	28	19	84	60	82	64
Jamaica	13	10	26	23	9	13
Japan	1	1	20	18	38	30
Lebanon	--	--	41	31	34	27
Mexico	43	36	81	65	17	17
New Zealand	2	1	14	9	62	43
Peru	4	5	--	--	20	21
Philippines	1	1	--	--	62	50
South Africa, Republic of	101	90	166	145	132	131
Spain	--	--	--	--	70	59
Sweden	--	--	--	--	39	24
Taiwan	--	--	4	3	40	31
Thailand	--	--	22	13	66	38
United Kingdom	119	124	156	169	2	7
Venezuela	34	32	120	106	97	101
Other	29	31	139	108	177	149
Total	1,686	1,486	2,419	2,138	2,480	2,100

[1] Less than ½ unit.

Table 30.—U.S. exports of zinc, by class

Year	Slabs, pigs, or blocks Quantity (short tons)	Slabs, pigs, or blocks Value (thousands)	Sheets, plates, strips, or other forms, n.e.c. Quantity (short tons)	Sheets, plates, strips, or other forms, n.e.c. Value (thousands)	Zinc scrap and dross (zinc content) Quantity (short tons)	Zinc scrap and dross (zinc content) Value (thousands)	Semifabricated forms, n.e.c. Quantity (short tons)	Semifabricated forms, n.e.c. Value (thousands)
1971	13,346	$2,337	1,686	$1,486	2,000	$504	6,042	$2,709
1972	4,324	714	2,419	2,138	1,446	431	6,052	3,076
1973	14,566	8,259	2,480	2,100	7,032	2,717	15,077	10,565

Table 31.—U.S. exports of zinc pigments

Kind	1972 Quantity (short tons)	1972 Value (thousands)	1973 Quantity (short tons)	1973 Value (thousands)
Zinc oxide	6,172	$2,306	7,638	$3,083
Lithopone	1,395	458	986	357
Total	7,567	2,764	8,624	3,440

Table 32.—U.S. imports for consumption of zinc, by country

Country	1971 Quantity (short tons)	1971 Value (thousands)	1972 Quantity (short tons)	1972 Value (thousands)	1973 Quantity (short tons)	1973 Value (thousands)
ORES [1]						
Australia	3,188	$720	926	$186	1,248	$181
Bolivia	4,738	696	77	21	5	1
Brazil	--	--	--	--	97	15
Canada	257,555	38,588	109,720	15,874	88,433	15,199
Germany, West	3,517	528	1,162	260	848	147
Guatemala	--	--	--	--	673	101
Honduras	22,486	2,934	3,680	547	15,987	2,325
Ireland	1,965	310	2,175	368	2,021	402
Mexico	121,016	14,925	39,282	4,530	30,802	4,314
Morocco	8,531	868	--	--	--	--
Nicaragua	--	--	--	--	1,330	155
Peru	44,256	3,088	8,000	1,304	12,451	1,827
South Africa, Republic of	100	19	9,041	1,185	--	--
Other	16	2	--	--	3	(2)
Total	467,368	62,678	174,063	24,275	153,898	24,667
BLOCKS, PIGS, OR SLABS						
Australia	37,096	11,634	41,079	14,863	41,415	18,892
Belgium-Luxembourg	9,365	2,701	39,616	13,998	39,412	20,789
Bulgaria	--	--	--	--	221	199
Canada	149,700	42,698	272,493	92,255	344,697	148,235
Ecuador	--	--	909	301	121	46
Finland	32,417	9,270	5,102	1,416	14,183	5,581
France	2,211	752	11,825	4,225	10,671	5,667
Germany, West	6,138	1,772	31,358	11,551	8,203	4,562
Japan	8,705	2,308	30,072	10,968	42,668	19,039
Mexico	10,130	2,442	8,394	2,276	1,913	732
Netherlands	18,745	5,849	14,001	5,096	3,036	1,997
Norway	2,205	329	--	--	220	300
Peru	24,412	7,283	30,625	9,760	19,343	7,171
Poland	2,508	729	4,418	1,584	13,277	8,927
South Africa, Republic of	4,740	1,422	--	--	329	264
Spain	5,071	1,475	1,102	381	11	10
Taiwan	--	--	--	--	221	112
U.S.S.R	--	--	--	--	3,599	2,777
United Kingdom	745	196	1,553	563	8,254	5,254
Yugoslavia	138	39	1,543	589	6,792	6,984
Zaire	8,898	2,444	22,493	6,860	28,440	12,488
Zambia	315	91	--	--	273	140
Other	716	194	60	21	130	47
Total	324,255	93,628	516,643	176,707	587,429	270,213

[1] Does not include zinc ores and concentrates for refining and export, as follows: 1971—Canada 11,791 short tons ($1,816,250); Mexico 14 short tons ($2,723); Peru 1,657 short tons ($298,278); Ireland 10 short tons ($981); Republic of South Africa 82 short tons ($7,450). 1972—Canada 4,787 short tons ($735,225); Mexico 171 short tons ($27,437); Ireland 176 short tons ($17,439); the Netherlands 98 short tons ($17,595); Belgium-Luxembourg 16 short tons ($2,690). 1973—Canada 3,979 short tons ($790,625); Mexico 11,816 short tons ($1,832,675); Honduras 875 short tons ($126,607); Nicaragua 5,431 short tons ($363,030); Peru 1,287 short tons ($516,447); Ireland 156 short tons ($15,467).

[2] Less than ½ unit.

Table 33.—U.S. general imports of zinc, by country

Country	1971 Quantity (short tons)	1971 Value (thousands)	1972 Quantity (short tons)	1972 Value (thousands)	1973 Quantity (short tons)	1973 Value (thousands)
ORES						
Australia	2,857	$201	5,871	$239	7,282	$288
Canada	209,084	30,027	135,534	19,483	124,261	22,057
Germany, West	--	--	1,162	260	848	147
Guatemala	138	13	723	130	--	--
Honduras	21,512	3,230	17,370	2,415	6,029	539
Ireland	3,975	657	5,978	885	2,001	401
Japan	--	--	--	--	519	93
Mexico	89,845	11,099	57,315	7,106	33,878	5,057
Nicaragua	--	--	10,960	1,163	11,244	1,324
Peru	15,025	2,375	15,256	2,007	12,981	1,812
South Africa, Republic of	61	11	4,690	779	--	--
Other	24	3	9	(1)	10	(1)
Total	342,521	47,616	254,868	34,467	199,053	31,718
BLOCKS, PIGS, OR SLABS						
Australia	38,552	12,056	39,623	14,441	42,076	19,256
Belgium-Luxembourg	9,365	2,701	39,616	13,998	39,908	21,186
Bulgaria	--	--	--	--	221	199
Canada	150,868	43,050	271,130	91,826	344,697	148,235
Ecuador	--	--	909	301	121	46
Finland	31,702	9,348	8,583	2,572	14,183	5,581
France	2,211	752	11,825	4,225	10,727	5,705
Germany, West	3,661	1,085	31,358	11,551	8,203	4,562
Japan	8,705	2,308	30,072	10,968	42,668	19,039
Mexico	10,130	2,442	8,394	2,276	1,913	732
Netherlands	13,283	4,220	14,001	5,096	3,229	2,095
Norway	2,205	329	--	--	220	300
Peru	23,873	7,132	30,625	9,760	19,343	7,171
Poland	2,618	764	4,199	1,514	13,168	8,873
Romania	1,221	354	5,526	1,603	--	--
South Africa, Republic of	4,740	1,422	--	--	329	264
Spain	5,071	1,475	1,102	381	11	10
U.S.S.R.	--	--	--	--	3,599	2,777
United Kingdom	800	210	1,553	563	8,474	5,365
Yugoslavia	138	39	1,543	589	6,792	6,984
Zaire	8,898	2,444	22,493	6,860	28,440	12,488
Zambia	315	91	--	--	273	140
Other	1,212	332	60	21	130	47
Total	319,568	92,554	522,612	178,545	588,725	271,055

1 Less than ½ unit.

Table 34.—U.S. imports for consumption of zinc, by class

Year	Ore (zinc content) Quantity (short tons)	Ore (zinc content) Value (thousands)	Blocks, pigs, slabs Quantity (short tons)	Blocks, pigs, slabs Value (thousands)	Sheets, plates, strips, other forms Quantity (short tons)	Sheets, plates, strips, other forms Value (thousands)
1971	467,368	$62,678	324,255	$93,628	509	$237
1972	174,063	24,275	516,643	176,707	485	310
1973	153,898	24,667	587,429	270,213	236	159

Year	Old and worn out Quantity (short tons)	Old and worn out Value (thousands)	Dross and skimmings Quantity (short tons)	Dross and skimmings Value (thousands)	Zinc dust Quantity (short tons)	Zinc dust Value (thousands)	Total value 1 (thousands)
1971	1,114	$147	853	$140	8,184	$2,949	$159,779
1972	814	235	2,068	r 357	9,197	3,822	r 205,706
1973	1,537	583	2,515	491	4,671	2,298	298,411

r Revised.
1 In addition, manufactures of zinc were imported as follows: 1971—$1,346,752; 1972—$2,040,029; 1973—$3,406,781.

Table 35.—U.S. imports for consumption of zinc pigments and compounds

Kind	1972		1973	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Zinc arsenate	1	$10	--	--
Zinc oxide	19,349	5,647	27,488	$11,256
Zinc sulfide	534	206	854	428
Lithopone	84	17	84	29
Zinc chloride	1,490	257	2,054	536
Zinc sulfate	3,944	475	4,410	699
Zinc cyanide	93	70	102	52
Zinc hydrosulfite	20	7	20	7
Zinc compounds, n.s.p.f	419	202	1,467	785
Total	25,934	6,891	36,479	13,792

Table 36.—Zinc: World mine production (content of ore), by country

(Short tons)

Country [1]	1971	1972	1973 p
North America:			
Canada [2]	1,397,246	1,409,388	1,489,331
Guatemala (exports)	558	340	309
Honduras	25,236	25,678	21,681
Mexico	292,081	299,656	299,137
Nicaragua	4,471	19,285	12,228
United States	502,543	478,318	478,850
South America:			
Argentina	r 48,351	49,318	44,864
Bolivia [3]	49,689	46,372	56,206
Brazil	r 18,651	19,600	e 32,000
Chile	r 2,185	1,281	1,766
Colombia	123	r e 95	NA
Ecuador	139	54	60
Peru	r 350,615	415,020	456,062
Europe:			
Austria	23,229	22,575	24,417
Bulgaria	r 88,000	r e 88,000	e 88,000
Czechoslovakia	9,440	10,210	e 11,000
Finland	56,093	54,998	64,587
France	16,689	14,650	14,700
Germany, East e	11,000	r 8,800	6,600
Germany, West	145,487	134,188	135,368
Greece	15,664	18,739	23,038
Greenland	--	--	50,800
Hungary e	5,300	5,300	5,300
Ireland	96,500	104,500	75,830
Italy	116,700	113,075	85,976
Norway	11,813	17,562	21,323
Poland	213,400	215,000	e 230,000
Portugal	2,255	1,971	769
Romania (recoverable) e	43,900	44,000	46,000
Spain	96,496	98,612	104,069
Sweden	109,176	125,364	126,400
U.S.S.R. e	717,000	717,000	740,000
Yugoslavia	108,791	106,628	110,000
Africa:			
Algeria	17,413	16,400	15,900
Congo, Republic of (Brazzaville)	r 698	2,373	e 2,400
Morocco	13,600	21,500	20,171
South Africa, Republic of	174	2,215	18,756
South-West Africa, Territory of [4]	r 48,167	38,296	41,798
Tunisia	13,000	11,200	8,800
Zaire	r 120,400	110,500	97,600
Zambia (smelter)	62,904	66,711	58,814
Asia:			
Burma	r 4,413	4,428	4,402
China, People's Republic of e	110,000	110,000	110,000
India	9,089	9,776	13,682
Iran e [5]	64,000	66,000	66,000
Japan	324,541	309,911	290,964
Korea, North e	149,000	154,000	160,000
Korea, Republic of	31,042	39,600	53,077
Philippines	4,271	5,074	5,921
Thailand [6]	(7)	(7)	132
Turkey	26,705	27,155	24,486
Oceania:			
Australia	r 498,957	558,155	526,395
New Zealand	r 2,170	1,821	1,423
Total	r 6,079,365	6,220,692	6,377,392

e Estimate. p Preliminary. r Revised. NA Not available.

1 In addition to the countries listed, North Vietnam also produces zinc, but available information is inadequate to make reliable estimates of output levels.

2 Zinc content of concentrates.

3 Sum of production by COMIBOL and exports by medium and small mines.

4 All data for 1971 are for fiscal year ending June 30, 1971; data for 1972 and 1973 are a summation of company figures for calendar year 1972 and 1973 for Tsumeb Corp. Ltd. and for fiscal year ending June 30, 1972, and June 30, 1973, for Rosh Pinah mine and Berg Aukas mine. Output of Tsumeb Corp. Ltd. for period July 1, 1971, through December 31, 1971 (which is not otherwise covered in this table), was 3,161 short tons.

5 Year beginning March 21 of year stated.

6 Contained in zinc concentrates. Additional quantities of zinc may be contained as a byproduct in lead concentrates produced, but information is inadequate to make reliable estimates of such production, if any.

7 Revised to zero.

Table 37.—Zinc: World smelter production by country

(Short tons)

Country [1]	1971	1972	1973 p
North America:			
Canada	410,030	524,885	587,038
Mexico	85,828	87,499	74,112
United States	766,433	633,180	541,319
South America:			
Argentina	r 36,900	43,200	40,896
Brazil	r 17,930	17,149	24,582
Peru	63,048	74,032	73,959
Europe:			
Austria [2]	17,603	18,604	18,738
Belgium [2]	r 234,475	283,700	309,847
Bulgaria [2]	86,400	88,200	88,200
Finland	70,219	89,393	89,206
France	241,027	288,271	284,184
Germany, East [e] [2]	17,000	17,000	20,000
Germany, West	r 121,700	235,500	265,560
Italy	r 153,132	171,807	209,530
Netherlands	45,600	55,400	33,600
Norway	68,963	80,851	88,740
Poland [2]	242,500	251,300	259,000
Romania [e]	43,900	44,000	46,300
Spain	94,436	109,854	117,860
U.S.S.R. [e]	717,000	717,000	740,000
United Kingdom	128,379	81,379	92,385
Yugoslavia [2]	58,543	53,617	60,821
Africa:			
South Africa, Republic of	r 47,800	52,000	58,533
Zaire	r 69,085	73,139	74,678
Zambia	62,904	61,711	58,814
Asia:			
China, People's Republic of [e]	110,000	110,000	110,000
India	23,443	27,808	14,010
Japan	789,660	887,114	928,984
Korea, North [e]	110,000	132,000	143,000
Korea, Republic of	r 9,856	11,576	13,878
Oceania: Australia	r 285,165	324,820	327,578
Total	r 5,228,959	5,645,989	5,795,352

e Estimate. p Preliminary. r Revised.

[1] In addition to the countries listed, North Vietnam also produces zinc, but available information is inadequate to make reliable estimates of output levels.

[2] Includes production from reclaimed scrap.

Zirconium and Hafnium

By Sarkis G. Ampian [1]

Zircon production and sales by domestic mining companies were over 20% higher in 1973 than in 1972. Zircon exports increased 67% from 17,360 tons in 1972 to 28,921 tons in 1973 while imports increased 45% from 67,537 tons in 1972 to 98,023 tons in 1973. Exports of zirconium oxide rose in 1973 while zirconium metal, and zirconium alloy exports declined. Production of zirconium-bearing compounds for chemicals and refractories also increased. Zircon consumption by foundries increased slightly from 92,000 tons in 1972 to 92,500 tons in 1973.

The 1973 worldwide zircon supply-demand picture was characterized by a diminishing supply coupled with an unprecedented demand. Domestically, zircon reflected the worldwide situation and also was in tight supply because of an increased demand, mainly in manufacturing specialized refractories and abrasives. This increased domestic zircon demand was sufficient to offset the increased supply brought about by the return of zircon imports to normalcy and advances in domestic production.

Legislation and Government Programs.—The Statistical Supplement to the Stockpile Report to Congress, December 31, 1973, showed no objectives for zirconium and hafnium materials. Stocks of 15,998 tons of Brazilian baddeleyite and 1 ton of zirconium metal powder were in excess. The U.S. Atomic Energy Commission (AEC) had an inventory as of June 30, 1973, of approximately 1 ton of zirconium crystal bar and scrap; 937 tons of zirconium sponge; 84 tons of Zircaloy ingot and shapes; 2 tons of hafnium scrap; 47 tons of hafnium oxide; one-half ton of hafnium sponge and shapes; and 39 tons of hafnium crystal bar.

[1] Physical scientist, Division of Nonmetallic Minerals—Mineral Supply.

Table 1.—Salient zirconium statistics in the United States

(Short tons)

Product	1969	1970	1971	1972	1973
Zircon:					
Production	W	W	W	W	W
Exports	5,395	4,335	9,429	17,360	28,921
Imports	95,414	94,759	96,387	67,537	98,023
Consumption [e 1]	160,000	145,000	166,000	168,000	175,000
Stocks, yearend, dealers and consumers [2]	53,000	52,000	42,500	44,500	51,500
Zirconium oxide:					
Production [3]	5,702	4,957	10,770	12,020	14,300
Producers' stocks, yearend [3]	1,005	1,050	680	942	648

[e] Estimate. W Withheld to avoid disclosing individual company confidential data.
[1] Includes baddeleyite: 1969—383 tons; 1970—355 tons; 1971—871 tons; 1972—385 tons; 1973—1,019 tons.
[2] Excludes foundries.
[3] Excludes oxide produced by zirconium metal producers.

DOMESTIC PRODUCTION

E. I. du Pont de Nemours & Co. and Titanium Enterprises, Inc., were the only major producers of zircon mineral concentrate in the United States. Zircon was recovered from mineral sands at the dredging and milling facilities owned by du Pont at Starke, Fla.; by Humphreys Mining Co. for du Pont, near Folkston, Ga.;

and Titanium Enterprises at Green Cove Springs, Fla. Production data were withheld from publication to avoid disclosing individual company confidential data. The combined zircon capacity of these three plants is estimated to be 135,000 tons per year.

Statistical data on production of zirconium sponge, ingot, and scrap and on hafnium sponge and oxide are also withheld to avoid disclosure of company confidential data. However, it was estimated that the total domestic sponge metal capacity was increased 50% in 1973 to approximately 7 million pounds per year to accommodate the demand for publicly announced ordnance purchases. The U.S. consumption of zirconium metal during the year was an estimated 6 million pounds, with 1.5 million pounds consumed in other free economies.[2]

Approximately 5,000 tons of alloys containing from 3% to 70% zirconium was produced in 1973.

Three firms produced 49,000 tons of milled (ground) zircon, an increase of 9% from the reported 1972 production. Six companies, excluding those that produce metal, produced 14,300 tons of zirconium oxide. Oxide production in 1973 increased nearly 12% over that reported in 1972.

Hafnium crystal bar, produced by several firms, amounted to 41 tons, compared with 40 tons in 1972.

[2] Couch, G. R. Zirconium—Nuclear Market Will Fuel Demand Growth. Eng. & Min. J., v. 175, No. 3, March 1974, pp. 135–136.

Table 2.—Producers of zirconium and hafnium materials in 1973

Company	Location	Materials
ZIRCONIUM MATERIALS		
AMAX Specialty Metals Corp	Akron, N.Y	Ingot, sponge.
Do	Parkersburg, W. Va	Sponge, metal chloride, oxide.
Associated Metals and Minerals Corp	New York, N. Y	Zircon.
Barker Foundry Supply Co	Los Angeles, Calif	Milled zircon.
The Carborundum Co	Falconer, N. Y	Refractories.
C. E. Refractories, Div. of Combustion Engineering, Inc.	St. Louis, Mo	Do.
	King of Prussia, Pa.	Refractories, zircon.
Continental Mineral Processing Corp	Sharonville, Ohio	Milled zircon.
Corhart Refractories Co	Buckhannon, W. Va	Refractories.
Do	Corning, N. Y	Do.
Do	Louisville, Ky	Do.
E. I. du Pont de Nemours & Co	Wilmington, Del	Zircon, foundry mixes.
Foote Mineral Co	Cambridge, Ohio	Alloys.
Do	Exton, Pa	Do.
A. P. Green Refractories Co., Remmey Division	Philadelphia, Pa	Refractories.
Harbison-Walker Refractories Co	Mount Union, Pa	Do.
Harshaw Chemical Co., Inc	Cleveland, Ohio	Oxide, ceramics.
Hercules, Inc	Washington, Pa	Ceramics, milled zircon.
O. Hommel Co	Pittsburgh, Pa	Milled zircon.
Ionarc/TAFA	Bow, N. H	Oxide.
Lava Crucible Refractories	Zelienople, Pa	Refractories.
Leco Corp	St. Joseph, Mich	Do.
M & T Chemicals, Inc	Andrews, S. C	Milled zircon.
Magnesium Electron, Inc	Secaucus, N. J	Alloys, chemicals.
N L Industries, Inc., Titanium Alloy Manufacturing Div. (TAM).	Niagara Falls, N. Y	Milled zircon, oxide, alloys, chloride.
Norton Co	Huntsville, Ala	Oxide.
Nuclear Materials & Equip. Corp	Leechburg, Pa	Powder.
Ohio Ferro-Alloys Corp	Brillant, Ohio	Alloys.
Ronson Metals Corp	Newark, N. J	Baddeleyite (oxide).
Sherwood Refractories Co	Cleveland, Ohio	Zircon cores.
Shieldalloy Corp	Newfield, N. J	Welding rods, alloys.
The Charles Taylor Sons Co	Cincinnati, Ohio	Refractories.
Do	South Shore, Ky	Do.
Teledyne Wah Chang Albany Corp	Albany, Oreg	Oxide, chloride, sponge, ingot, powder, crystal bar.
Titanium Enterprises, Inc	Green Cove Springs, Fla.	Zircon.
Tizon Chemical Corp	Flemington, N. J	Oxide, other chemicals.
Transelco, Inc	Dresden, N. Y	Other chemicals, ceramics.
T. R. W., Inc	Cleveland, Ohio	Zircon cores.
Do	Minerva, Ohio	Do.
Union Carbide Corp	Alloy, W. Va. and Niagara Falls, N. Y.	Alloys.

Table 2.—Producers of zirconium and hafnium materials in 1973—Continued

Company	Location	Materials
ZIRCONIUM MATERIALS—Continued		
Ventron Corp	Beverly, Mass	Alloys, oxide, sponge.
Zedmark, Inc	Butler, Pa	Refractories.
Zirconium Corp. of America	Cleveland, Ohio	Oxide, refractories, ceramics.
HAFNIUM MATERIALS		
AMAX Specialty Metals Corp	Akron, N. Y	Sponge, crystal bar, ingot, scrap.
Do	Parkersburg, W. Va	Oxide.
Nuclear Materials & Equipment Corp	Leechburg, Pa	Crystal bar.
R. M. I. Co	Ashtabula, Ohio	Sponge, crystal bar.
Teledyne Wah Chang Albany Corp	Albany, Oreg	Oxide, sponge, crystal bars, ingot.

CONSUMPTION AND USES

Zircon consumption in the United States in 1973 was estimated at 175,000 tons. Consumption of zircon concentrate and milled zircon was 92,500 tons for foundries, 27,000 tons for refractories, 22,000 tons for zirconium oxide, 3,500 tons for zirconium alloys (excluding zirconium-base alloys), and 30,000 tons for all other uses. Foundries consumed approximately one-half of the domestic zircon production, with the remaining half consumed by refractory, abrasive, ceramic, metal, and other industries. Domestic zircon was also marketed in proprietary mixtures for use as weighting agents, zircon TiO_2 blends for welding rod manufacture, and zircon-refractory heavy mineral (kyanite, sillimanite, and staurolite) sand blends, for foundry sand and sandblasting applications. The zircon-bearing foundry sand was reportedly designed to provide consistent high-quality performance at low cost for critical casting applications.

Imported Republic of South Africa baddeleyite ore in 1973 was used principally in the manufacture of alumina-zirconia abrasives and also in ceramic colors, refractories, and for other uses.

Preliminary Bureau of the Census figures for 1973 showed that shipments of zircon and zirconia brick and shapes, composed mostly of these materials, totaled 2.3 million brick, expressed in terms of equivalent 9-inch brick, valued at $8.8 million. In 1972, final figures for shipments were 2.0 million brick valued at $8.3 million.[3]

Dealers and other firms reported shipments of milled zircon and concentrate in 1973 to the following markets: Foundry use, 46,000 tons; refractory and chemical use, 57,000 tons; chemical, metal, alloying, compounds, and other uses, 4,300 tons.

Zirconium metal was used in nuclear reactors, in chemical plants for corrosion-resistant material, in refractory alloys, and in photography for flashbulbs. AMAX and Wah Chang enlarged flat product mill capacities in 1973. AMAX began rolling zirconium metal in its Cleveland refractory metals mill: the mill was acquired from the General Electric Co. (G.E.). Wah Chang was planning to install Fansteel's Schloemann mill, recently acquired, at its Albany Oreg., plant.

Zirconium compounds, natural and manufactured, were used in refractories, glazes, enamels, welding rods, chemicals, and sandblasting. Zirconium chemicals were finding increasing applications in the paint, textile, and pharmaceutical industries. Ionarc/TAFA streamlined its pilot commercial-scale ZrO_2 plant. This new plant has a projected capacity of 1 million pounds per year of its unique plasma-produced zirconia. This highly reactive zirconia, readily soluble in sulfuric acid, was reported to be particularly suited for zirconia-based colors, chemicals, and polishes. Magnesium Elektron, Inc. (MEI), purchased the Tizon Chemical Corp. facility in Flemington, N. J. MEI planned to add zirconium chemicals to its line of magnesium-zirconium casting alloys. Tizon will continue furnishing its proprietary polishing mixtures containing zirconium chemicals.

Hafnium metal, alloys, and compounds continued to have few uses. The metal was used for nuclear reactor control rods, in special refractory alloys, and in photographic flashcubes. The nonnuclear hafnium metal uses were reportedly increasing.

[3] U.S. Department of Commerce, Bureau of the Census, Refractories. Quarterly, 1973.

Table 3.—Zircon consumption in selected zirconium materials as reported by producers in the United States in 1973

(Short tons)

Use	Quantity
Zircon refractories[1]	14,000
AZS refractories[2]	13,000
Zirconia[3]	22,000
Alloys[4]	3,500
Other[5]	30,000

[1] Dense and pressed zircon brick and shapes.
[2] Fused cast and bonded alumina-zirconia-silica-base refractories.
[3] Excludes oxide produced by zirconium metal producers.
[4] Excludes alloys above 90% zirconium.
[5] Includes chemicals, metallurgical-grade zirconium tetrachloride, sandblasting, and welding rods.

Table 4.—Zirconium oxide[1] consumption in selected zirconium materials as reported by producers in the United States in 1973

(Short tons)

Use	Quantity
AZ abrasives[2]	6,000
AZS refractories[3]	3,000
Other refractories	4,000
Chemicals	300
Glazes, opacifiers, and colors	1,000

[1] Excludes oxide produced by zirconium metal producers.
[2] Alumina and zirconia-based abrasives.
[3] Fused cast and bonded.

Table 5.—Yearend stocks of zirconium and hafnium materials

(Short tons)

Item	1972	1973
Zircon concentrate held by dealers and consumers excluding foundries	40,000	43,200
Milled zircon held by dealers and consumers, excluding foundries	4,500	8,300
Zirconium:		
Oxide[1]	1,300	648
Sponge	471	520
Ingot	W	342
Scrap	722	840
Alloys	285	1,190
Refractories	9,585	9,395
Hafnium:		
Sponge	25	28
Crystal bar	6	10

W Withheld to avoid disclosing individual company confidential data.
[1] Excludes oxide held by zirconium metal producers.

PRICES

Published prices for domestic and foreign zircon rose $5 and $30, respectively, from those of 1972. The prices of zirconium oxides and chemicals, zirconium hydride, zirconium metal powder and sponge, and hafnium metal products were relatively unchanged. The baddeleyite price was furnished by Ronson Metals Corp.

Table 6.—Published prices of zirconium and hafnium materials in 1973

Specification of material	Price
Zircon:	
Domestic, f.o.b. Starke, Fla. (Folkston, Ga.), bags, per short ton [1]	\$59.50 -\$60.50
Domestic, 75% minimum quantity zircon and aluminum silicates, Starke, Fla. (Folkston, Ga.), bags, per short ton	40.00
Imported sand, containing 65% ZrO_2, c.i.f. Atlantic ports, bags, per long ton [2]	95.00 -100.00
Domestic, granular, 30-ton lots, from works, bags per pound [3]	.0475
Domestic, milled, 15-ton lots, from works, bags, per pound [3]	.050
Baddeleyite imported concentrate: [4]	
98% to 99% ZrO_2, minus 100-mesh, c.i.f. Atlantic ports, per pound	.16 - .20
99 + %, minus 325-mesh, c.i.f. Atlantic ports, ton lots, per pound	.48 - .63
Zirconium oxide: [3]	
Powder, commercial-reactor grade, drums, from work, per pound [3]	6.50 - 8.00
Chemically pure white ground, barrels or bags, works, per pound [3]	1.50
Electric fused, lump, bags, works, per pound	.505- .530
Milled, bags, 5-ton lots, from works, per pound [3]	.64
Glass-polishing grade, 100-pound bags, 85% to 90% ZrO_2, works, per pound [3]	.71
Opacifier grade, 100-pound bags, 85% to 90% ZrO_2, per pound [3]	.42
Stabilized oxide, 100-pound bags, 91% ZrO_2, milled, per pound [3]	.80 - 1.10
Zirconium oxychloride: Crystal, cartons, 5-ton lots from works, per pound	.515
Zirconium acetate solution: [3]	
13% ZrO_2, drums, carload lots, from works, per pound	.22
22% ZrO_2, same basis	.38
Zirconium hydride: [3] Electronic grade, powder, drums, from works, per pound	14.50 - 16.00
Zirconium:	
Powder, per pound [5]	10.00
Sponge, per pound [2]	5.50 - 7.00
Sheets, strip, bars, per pound [2]	8.00 - 17.00
Hafnium: [5]	
Sponge, per pound	75.00
Bar and plate, rolled, per pound	120.00
Nitrided	34.25

[1] E. I. du Pont de Nemours & Co. Price List. December 1973.
[2] Metals Week. V. 44, No. 28, July 9, 1973, p. 4.
[3] Chemical Marketing Reporter. V. 204, No. 2, July 9, 1973, p. 39.
[4] Ronson Metals Corp. Baddeleyite Price List. Jan. 1, 1973.
[5] American Metal Market. V. 80, No. 183, Oct. 4, 1973, p. 19.

FOREIGN TRADE

Exports of zirconium ore and concentrate and zirconium oxide rose in 1973 compared with 1972 figures. Exports of all forms of zirconium metal and alloys, in general, were lower in 1973 than in 1972.

Zirconium ore and concentrate, exported to 13 countries in 1973, increased from 34,-719,653 pounds valued at \$940,347 in 1972 to 57,842,328 pounds valued at \$2,288,128. The quantity exported increased 67% over that shipped in 1972, but the value rose 43%. Both the 1973 quantity and value were alltime highs. The average value of the zirconium ore and concentrate exported in 1973, \$79.12 per ton, represented an increase from the 1972 value of \$54.17. This increase was attributed to larger amounts of higher cost granular and milled zircon shipped. The increase in the amount of higher cost zircon shipped also indicates a return to the normal zircon exporting pattern. Exports in 1972 consisted of a larger than normal percentage of lower cost zircon sand. The major recipients of the exported zirconium ore and concentrate were Japan, 39%; the Netherlands, 30%; Mexico 12%; Brazil, 11%; and Canada, 7%.

Exports of zirconium oxide increased from 1,304,352 pounds valued at \$931,867 in 1972 to 2,055,000 pounds valued at \$1,402,-167 in 1973. Export quantity and value increased 58% and 50%, respectively, in 1973. These zirconium oxide shipments were made to 21 countries. The five major recipients in 1973 were Japan, 32%; West Germany, 17%; Mexico, 15%; Canada, 13%; and Brazil, 7%.

Total exports of other classes of zirconium decreased nearly 23%, from 1,314,219 pounds in 1972 to 1,016,437 pounds in 1973. The value of this material rose 8% in 1973 to \$12,424,733 from the 1972 value of \$11,508,858. Of the three categories listed, only zirconium and zirconium alloy foil and leaf increased in both value and quantity in 1973. The zirconium and zirconium alloys, wrought class decreased 14% in the pounds exported but increased 21% in value, and exports of zirconium and zirconium alloys, unwrought, and waste and scrap decreased 54% in quantity and declined 51% in value.

Imports for consumption of zirconium ores in 1973 rose to 98,023 short tons, a 45% increase compared with the 67,537 short tons in 1972. The 1973 figure represents an alltime high tonnage of ore imported. Zirconium ore imports from the Republic of South Africa were chiefly baddeleyite (ZrO_2). The remaining zirconium ore imports were believed to be Australian zircon.

The average value of imported zircon at foreign ports increased 11% in 1973 to $51.76 per short ton, compared with $46.79 in 1972. The Republic of South Africa baddeleyite value in 1973 of $386.65 per short ton decreased slightly from the 1972 value of $387.01. The tonnage imported rose 165% in 1973.

Imports for consumption of zirconium and hafnium in 1973 increased both in quantity and value in all categories: Zirconium, wrought; zirconium, waste and scrap and unwrought; zirconium alloys, unwrought; zirconium compounds, n.e.c.; zirconium oxide; and hafnium, unwrought and waste and scrap. Wrought hafnium imports resumed in 1973.

Table 7.—U.S. exports of zirconium ore and concentrate, by country

Destination	1972		1973	
	Pounds	Value	Pounds	Value
Argentina	44,600	$4,207	10,400	$1,292
Brazil	3,231,931	84,856	6,604,182	618,234
Canada	3,284,383	181,203	4,034,229	243,319
Chile	66,922	5,306	--	--
Colombia	6,000	660	6,000	1,786
France	12,000	1,646	26,880	5,240
Guatemala	--	--	113,400	6,079
Ireland	144,553	8,995	74,646	3,907
Israel	1,143	617	--	--
Italy	--	--	75,000	4,200
Japan	79,728	9,675	22,432,164	622,172
Mexico	5,700,660	208,588	6,989,077	288,503
Netherlands	13,231,733	280,708	17,461,750	491,354
United Kingdom	8,916,000	153,886	2,000	1,065
Venezuela	--	--	12,600	977
Total	34,719,653	940,347	57,842,328	2,288,128

Table 8.—U.S. exports of zirconium by class and country

Country	1972		1973	
	Pounds	Value	Pounds	Value
Zirconium and zirconium alloys, wrought:				
Australia	102	$704	21	$563
Austria	61	730	--	--
Belgium-Luxembourg	144	2,095	16,177	581,474
Brazil	648	6,474	266	1,773
Canada	571,109	4,602,989	236,909	3,298,357
Denmark	--	--	112	1,208
France	879	6,805	13,016	439,210
Germany, West	125,448	838,697	213,515	1,788,895
India	2,266	97,080	4,234	38,794
Italy	2,863	76,950	806	20,626
Jamaica	1,168	13,895	--	--
Japan	102,677	2,094,776	99,117	2,400,364
Netherlands	3,179	39,704	1,068	8,313
Norway	19,146	177,740	6,144	59,541
Poland	--	--	48	570
Portugal	443	5,316	300	4,367
Sweden	58,328	564,202	70,932	684,683
Switzerland	1,001	4,785	15,132	724,127
United Kingdom	9,039	196,169	99,247	512,547
Total	898,501	8,729,111	777,044	10,565,412
Zirconium and zirconium alloys, unwrought and waste and scrap:				
Australia	708	3,170	23	536
Belgium-Luxembourg	1,758	20,035	3,241	38,660
Canada	8,270	68,070	4,797	32,665
France	8,218	64,705	2,120	9,498
Germany, West	78,072	471,506	23,830	143,400
Haiti	--	--	336	1,746
India	172	2,713	37	1,203
Italy	1,718	27,565	451	10,900
Japan	102,725	638,530	32,206	252,009
Korea, Republic of	--	--	160	1,810
Netherlands	969	4,340	--	--
Norway	1,148	9,329	3,275	31,936
Sweden	75	1,000	12,360	105,502
Switzerland	10,349	59,108	4,959	22,212
Thailand	179	1,084	--	--
United Kingdom	169,764	916,761	89,765	465,822
Yugoslavia	27	696	--	--
Total	384,152	2,288,612	177,560	1,117,899
Zirconium and zirconium alloy foil and leaf:				
Belgium-Luxembourg	2,118	35,462	2,743	38.086
Canada	16,096	305,295	10,481	148,807
Germany, West	--	--	39,045	440,653
Israel	--	--	47	558
Italy	2,192	41,678	5,995	78,020
Japan	--	--	2,432	23,724
Sweden	10,878	103,717	--	--
United Kingdom	282	4,983	1,090	11,574
Total	31,566	491,135	61,833	741,422

Table 9.—U.S. exports of zirconium oxide, by country

Country	1972 Pounds	1972 Value	1973 Pounds	1973 Value
Argentina	66,962	$54,233	45,481	$40,949
Australia	600	900	3,000	2,570
Austria	22,000	16,324	24,000	17,808
Belgium-Luxembourg	14,612	9,790	6,309	4,403
Bolivia	500	740	--	--
Brazil	136,805	96,235	144,993	102,024
Canada	152,986	99,018	277,165	186,959
Chile	2,000	1,530	400	592
Dominican Republic	--	--	1,049	1,492
France	49,382	47,357	60,111	45,783
Germany, West	344,319	243,131	344,471	249,178
Greece	1,500	1,200	3,500	2,971
Hong Kong	1,804	1,560	7,450	6,858
India	2,060	1,380	--	--
Israel	3,543	3,033	600	546
Italy	173,321	146,120	17,491	17,186
Japan	86,639	53,636	652,999	400,236
Mexico	92,285	63,581	311,753	200,776
Netherlands	83,960	52,139	37,546	25,620
Peru	635	853	635	896
South Africa, Republic of	500	666	3,667	2,457
Sweden	53,819	28,226	--	--
United Kingdom	13,520	9,327	111,280	91,235
Venezuela	600	888	1,100	1,628
Total	1,304,352	931,867	2,055,000	1,402,167

Table 10.—U.S. imports for consumption of zirconium ores, by country

Country	1971 Quantity (short tons)	1971 Value (thousands)	1972 Quantity (short tons)	1972 Value (thousands)	1973 Quantity (short tons)	1973 Value (thousands)
Australia	93,402	$3,328	66,064	$3,081	90,353	$4,747
Austria [1]	--	--	49	3	1	(2)
Canada [1]	2,114	49	844	49	1,179	82
Japan [1]	--	--	168	7	--	--
Malaysia	--	--	--	--	445	15
South Africa, Republic of	871	279	385	149	1,019	394
United Kingdom [1]	--	--	--	--	5,003	175
Venezuela	--	--	27	2	23	2
Total	96,387	3,656	67,537	3,291	98,023	5,415

[1] Believed to be country of shipment rather than country of origin.
rather than country of origin.
[2] Less than ½ unit.

Table 11.—U.S. imports for consumption of zirconium and hafnium 1973

Country	Pounds	Value
Zirconium, wrought:		
Canada	600	$8,000
France	133,715	1,127,417
Germany, West	783	20,890
Israel	1,349	550
Norway	29	628
Total	136,476	1,157,485
Zirconium, unwrought and waste and scrap:		
Canada	30,863	15,320
Germany, West	39,050	23,178
Japan	264,030	826,834
Switzerland	16,535	17,249
United Kingdom	18,597	19,008
Total	369,075	901,589
Zirconium alloys, unwrought: United Kingdom	9,443	3,717
Zirconium oxide:		
Canada	6,261	4,383
France	11,310	23,269
Germany, West	3,086	3,841
Japan	12,000	6,880
Switzerland	22	1,062
U.S.S.R	338,453	125,444
United Kingdom	113,753	52,056
Total	484,885	216,935
Zirconium compounds, n.e.c.:		
France	130,403	46,877
Germany, West	172,578	78,324
Japan	61,200	5,862
South Africa, Republic of	8,889	1,355
United Kingdom	2,900,581	981,494
Total	3,273,651	1,113,912
Hafnium, unwrought and waste and scrap:		
France	2,404	90,533
United Kingdom	25	634
Total	2,429	91,167
Hafnium, wrought: France	87	4,221

WORLD REVIEW

Australia.—Allied Eneabba Pty. Ltd., a joint venture of E. I. du Pont de Nemours & Co. and Allied Minerals N.L. on the latter's rutile prospect in Western Australia, revealed details of its future plans. Du Pont reportedly will provide both technical and financial assistance in constructing a pilot plant designed to produce 7,000 tons per year (tpy) of rutile, 15,000 tpy of zircon, and 28,000 tpy of ilmenite.[4]

Construction of a full-scale plant capable of producing 50,000 tpy of rutile, 200,000 tpy of ilmenite, 100,000 tpy of zircon, and unspecified quantities of monazite, leucoxene, and kyanite, was scheduled for completion in 1974. Du Pont has contracted to purchase 200,000 tons of ilmenite annually over a 15-year period.[5] It was estimated that the Allied Eneabba mineral field contains, in million tons, 14.0 of ilmenite, 6.3 of zircon, 2.2 of rutile, and 0.2 of monazite.[6]

Westralian Sands Ltd., a Western Australia mineral sands producer, announced setting up of a new open pit operation and a mill in the Yoganup Extended area, South of Capel, to meet increased demand. The mill includes a mobile concentrator and screening plant. Westralian Sands planned to begin mining at its Tutunup area properties upon cessation of its current mining operation between Yoganup and the Capel River. Exploration from Boyanup (between Capel and Bunbury) northwards has been undertaken in a joint venture with British Titan Products' subsidiary, Tioxide Australia Pty. Ltd., to develop the area if warranted, by a new subsidiary. Westralian Sands has also been exploring for heavy mineral sands north of Perth in association with Lennard Oil NL.[7]

[4] American Paint Journal. V. 58, No. 26, Dec. 10, 1973, p. 54.

[5] Industrial Minerals. No. 64, January 1973, p. 27.

[6] Allied Eneabba Pty. Ltd. (Subiaco, Western Australia). Company brochure. 1973, 12 pp.

[7] Work cited in footnote 5.

Table 12.—Zirconium concentrate: Non-Communist world production, by country
(Short tons)

Country	1971	1972	1973 p
Australia	r 455,195	397,042	393,336
Brazil [1]	4,956	5,046	e 5,100
India [2]	9,924	e 12,000	e 12,000
Malagasy Republic	3	15	e 15
Malaysia	2,803	2,216	e 2,200
South Africa, Republic of [3]	r 1,091	745	2,180
Sri Lanka	153	33	31
Thailand	1,682	403	e 440
United States	W	W	W
Total	r 475,807	417,500	415,302

e Estimate. p Preliminary. r Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Figure for 1971 includes 4,594 short tons of zircon and 362 short tons of baddeleyite; similar breakdown for 1972 and 1973 not available.
[2] Output of Indian Rare Earths Ltd. for year beginning April 1 of year stated.
[3] Official South African production figures are not reported; data presented are total recorded imports of zirconium ores and concentrates reported by the United States, Japan, and West Germany. As such, listed figures may be only a part of total output.

The Government of Western Australia was investigating the possibility of coordinated export facility at the Geraldton depot for the four new and existing mineral sand producers. Presently, Allied Eneabba was the first major producer to go onstream with a projected annual capacity of 350,000 tpy. A second producer, A. V. Jennings Industries (Australia) Ltd., was scheduled to begin production in 1974 with an initial capacity of 240,000 tpy of heavy minerals. The third party, Ilmenite Pty. Ltd., was planning to prove and test its reserves southwest of Eneabba by the end of 1974, prior to finalizing development plans. The fourth company, Westcoast Rutile Pty. Ltd. has located two deposits in the Jurien Bay area and hopes to complete a feasibility study for their development in the latter part of 1974.

This expansion in heavy mineral sand production is taking place along a 100-mile stretch of coast between Geraldton and Jurien Bay. This stretch of coast has proved and probable heavy mineral reserves exceeding 140 million tons.[8]

Mining Corp. of Australia (MCA), a company organized by Kamilaroi Mines Ltd. and Westcoast Rutile for exploiting their Jurien Bay properties, has revised its heavy mineral reserve estimates. The reserves now are 2 million tons of proved ore; 470,000 tons of probable reserves; and 600,000 tons of possible reserves. MCA also stated that the grade of ore is 8% to 9% heavy mineral at a cut-off grade of 3%.[9]

Canada.—Chase Brass Division of Kennecott Copper Corp. and Noranda Metals Corp. announced plans to construct two tubular production plants near Ottawa, capable of producing zirconium fuel cladding. These plants will use zirconium alloys supplied by both AMAX and Teledyne Wah Chang.[10]

France.—The diversified St. Gobain-Pont-à-Mousson group was expected to gain control of Sté. Générale des Produits Réfractaires S.A. (SGPR), one of France's major manufacturers, by acquiring Péchiney-Ugine-Kuhlmann's holdings. SGPR produces a wide range of clay and nonclay refractories. St. Gobain also increased its shareholdings in l'Electro-Réfractaire (fused cast refractories), in 1972, by purchasing shares held by Corning Glass, Co. U.S.A., and formed a partnership with the Italian company, Montedison, Refradige S.p.A., to produce fused cast refractories in Italy.[11]

India.—The capacity of the Chavara dry plant, operated by the Indian Rare Earths Ltd., near Quilon, was being expanded to yield over 200,000 tpy of ilmenite with proportionate increases in the output of zircon.[12] The other company plant at Manavalakurichi, Kerala State, underwent an expansion to 40,000 tpy a few years ago. The two principal destinations for Indian heavy minerals were Japan and Czechoslovakia.[13]

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[8] Industrial Minerals. No. 67, April 1973, p. 28.
[9] Industrial Minerals. No. 74, November 1973, p. 20.
[10] Work cited in footnote 2.
[11] Page 28 of work cited in footnote 5.
[12] Industrial Minerals. No. 69, June 1973, p. 35.
[13] Engineering and Mining Journal. This Month in Asia. V. 174, No. 4, April 1973, p. 174.

The Industrial and Investment Corp. of Mahrashtra was examining the State's beach sand deposits for feasibility of producing beneficiated titanium products and associated heavy minerals.[14]

Sierra Leone.—Heavy mineral sand operations at the Bonthe and Moyamba mines, relinquished by Sherbro Mining Ltd. 2 years ago, were reopened by a subsidiary of two West German companies, the Bayer-Preussag Mining Co. Details regarding rutile and zircon production were unannounced.[15]

South Africa, Republic of.—A pilot plant to recover titaniferous and zircon-bearing heavy minerals from the dune area sands north of Richards Bay, Natal, has been put onstream by the Industrial Development Corp. of South Africa, in association with King Resources S.A. Pty. Ltd. The pilot plant was to provide sufficient information to decide if full-scale exploitation is possible.[16] The Phosphate Development Corp. Ltd. (FOSKOR) was undergoing expansion to enable an eventual twofold increase in the production capacity for its unique baddeleyite concentrates. The baddeleyite concentrates, pure and ultrapure were favorably received by the abrasive and ceramic industries. Palabora Mining Co. Ltd. (PMC), mining a contiguous deposit in the Palabora igneous complex, was also undergoing an expansion. A market survey conducted earlier by PMC indicated a strong demand for its stockpiled baddeleyite. The baddeleyite concentrates are coproducts from copper, phosphate, and iron operations.

Tanzania.—The Tanzania State Mining Corporation reported coastal deposits containing zircon, ilmenite, rutile, and other heavy minerals.

TECHNOLOGY

The Office of Coal Research (OCR), U.S. Department of the Interior, completed negotiations with the U.S.S.R. for joint research on the magnetohydrodynamic (MHD)[17] method of generating electricity.[18] In further MHD research the OCR also let a contract to G.E., Philadelphia, Pa.,[19] and announced a cooperative effort with the U.S. Air Force.[20]

The joint U.S.-U.S.S.R. MHD research will capitalize on the experience gained from the minimally operating 25-megawatt MHD pilot plant in Moscow. An exchange of scientific MHD data should prove mutually beneficial in achieving the rapid commercialization of MHD generating systems. The contract with GE was awarded to improve high-temperature operations required by advanced systems for generating electricity from coal. G.E. was to provide for the experimental work at its Space Sciences Laboratory, Valley Forge, Pa. The work involves construction and operation of a pilot heat exchanger to determine its effectiveness towards increasing the temperatures for coal gas fired, closed cycle MHD systems. The U.S. Air Force and OCR cooperative effort was to be done at the Air Force's Arnold Engineering Development Center, Tullahoma, Tenn., and was to demonstrate the higher efficiency of a coal-based MHD generator compared with conventional steam-generating plants. The Air Force was providing both the research facilities and the MHD generator. This effort, started at yearend, was to be done by ARO, Inc., a civilian operating contractor for the Arnold Center.

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[14] Industrial Minerals. No. 72, October 1973, p. 55.

[15] Engineering and Mining Journal. This Month in Mining-In-Africa. V. 174, No. 12, December 1973, p. 114.
Industrial Minerals. No. 72, September 1973, pp. 32–34.

[16] Mining Magazine (London). V. 129, No. 5, November 1973, p. 463.

[17] MHD involves generating electricity without rotating parts associated with the less efficient conventional steam turbine generating systems. Coal-fired MHD systems are fired at high temperatures and pressures and the resulting gases are forced through a duct at high velocities. The gases move through a magnetic field surrounding the duct, resulting in the generation of an electric current. The ultra-high-temperature MHD systems are more efficient than lower temperature MHD systems and use stabilized zirconia electrodes and insulator materials in the ducts.

[18] U.S. Department of the Interior. Interior Announces Cooperative MHD Research With Soviet Union. Press Release July 20, 1973, 1 p.

[19] U.S. Department of the Interior. OCR Awards $94,853 Contract to Improve MHD Systems. Press Release, Nov. 30, 1973, 1 p.

[20] Coal Mining and Processing. V. 11, No. 6, June 1974, p. 22.

Bureau of Mines research efforts were directed towards zirconium electrowinning technology and developing advanced molybdenum-zirconium alloys. The zirconium electrowinning research goals were twofold. The initial goal was to lower the cost of producing electrowon zirconium by a Bureau-developed process and the second goal was to operate a 1,000-ampere cell for meaningful upscaling evaluations. The Bureau of Mines electrolytic process uniquely produces a high-purity metal remarkably low in interstitial contaminants. The advanced molybdenum-zirconium alloy research consists of three integrated phases: 1. Castability of alloys; 2. Stable oxide coatings; and 3. Casting oxidation resistance metal protective coatings. The compositions included in this research were TZM (Mo-0.5Ti-0.08Zr—0.015C) and binary molybdenum alloys containing various levels of zirconium and hafnium.

Bureau of Mines research in the K_2HfF_6-K_2ZrF_6—1.25 weight-percent HF systems revealed even though hafnium enrichment can be obtained in recrystallized liquors, the existence of hydrates coupled with the slopes of their connecting solubility curves precludes the suitability of this system in separating high-purity K_2HfK_6 from K_2HfF_6-K_2ZrF_6 mixtures.[21]

The history, geology, mining, and processing methods, along with shipping and quality control particulars, of the Allied Eneabba western Australian deposit, were related to present and future mining operations.[22] A detailed discussion of the Richert cone concentrator, a high-capacity, low-cost gravity pinch sluice-type, developed by Mineral Deposits Ltd. of Southport, Queensland, Australia, was published.[23] The detailed discussion includes not only flowsheets for several Australian heavy sand operations but also flowsheets for recovering cassiterite, baddeleyite, and magnetite from sand and nonsand ores.

The solid-liquid interfacial parameters of the zircon-sodium oleate (soap) system were experimentally determined by absorption measurements, zeta-potential, and infrared studies and correlated with parallel flotation experiments on high-purity zircon. The studies, mutually supporting, showed that the adsorption of sodium oleate on zircon is due mostly to a van der Waals-type attraction between the hydrocarbon chains of the fatty acid soap.[24] The completion of this theoretical study, directly applicable to soap-floating zircon from beach and other sands, was reported.[25] This work, devoted to determining the effects of pH on the flotation recovery of zircon from different sodium oleate concentrations, discovered the antagonistic role of hydroxyl ions with increasing pH. Recoveries of 100% zircon were experienced between the pH range of 6 to 9 at sodium oleate concentrations of 6.58 times 10^{-4} mole per liter. Zircon recoveries at other concentrations and pH were markedly lower.

Semicrystalline glazes, containing zirconia to improve opacity and acid resistance, compatible with low expansion cordierite white bodies were developed.[26] These glazes, reportedly attractive with a satin finish, consist of low expansion crystals dispersed in a vitreous or glassy matrix; they are suitable for application to the popular new dinnerware and cookware. Instability of reheated plasma-sprayed zircon coatings were attributed to the destabilization of the resulting dense cubic zirconia to the less dense monoclinic variety. The cubic zirconia crystallites, dispersed in a glassy silica matrix, on heating, undergoes a polymorphic transformation which results in a destructive pore contraction and/or shrinkage phenomenon.[27]

An article evaluated the considerations in selecting coreless induction furnace refractories. Vibrated monolithic silica linings, although dry, are preferable for these furnaces; circumstances are stressed in which brick or composite linings, such as zircon, zirconia, alumina, and magnesia, would be the better choice. Physiochemical and eco-

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21 Rhoads, S. C. The K_2HfF_6-K_2ZrF_6—1.25 Percent HF Systems at 40° C with Other Solubility Curves From 25° to 75° C. BuMines RI 7785, 1973, 20 pp.

22 Work cited in footnote 6.

23 Graves, R. A. The Richert Cone Concentractor—an Australian Innovation. Min. Cong. J., v. 59, No. 6, June 1973, pp. 24–28.

24 Dixit, S. G., and A. K. Biswas. Studies on Zircon-Sodium Oleate Flotation System: 1-Solid-Liquid Interfacial Parameters. Inst. Min. Met., v. 82, No. 802, September 1973, pp. C140–C144.

25 ———. Studies on Zircon-Sodium Oleate Flotation System: 2-pH Dependence of Collector Adsorption and Critical Contact Phenomena. Inst. Min. Met., v. 82, No. 805, December 1973, pp. C202–C206.

26 O'Conor, E. F., and R. A. Eppler. Semicrystalline Glazes for Low Expansion Whiteware Bodies. Bull. Am. Ceram. Soc., v. 52, No. 2, February 1973, pp. 180–184.

27 Whittemore, Jr., O. J., and D. A. Sullivan. Pore Changes on Reheating of Plasma-Sprayed Zircon. J. Am. Ceram. Soc., v. 56, No. 6, June 1973, p. 347.

nomic considerations are also weighed.[28] The occurrences of known Canadian mineral deposits suitable for clay and nonclay refractories production, irrespective of economics, were highlighted. The majority of the reported zircon occurrences were in Ontario.[29]

The lanthanum modified lead zirconate-lead titanate (PLZT) polycrystalline bodies, aside from their usefulness as electrooptic (electric switching and/or memory application) materials, when suitably hot-pressed have especially useful light optical transparency at near theoretical densities. However, the development of commercially acceptable light transparent PLZT bodies have been hampered because of reduced light transparency or opaqueness due to deviations from their theoretical density. These deviations were traced to the presence of pores or voids which contributed to opaqueness by a light-scattering mechanism. Methods to both calculate the expected transparency and relate it to deviations from theoretical density were advanced. This calculating technique should hasten the development of commercial PLZT bodies.[30] Mechanisms and systems, including improvements in atmospheric sintering processes were used successfully in fabricating transparent PLZT plates over 8.4 centimeters in diameter. A combined cold- and hot-pressing scheme, limiting the rate of lead oxide volatilization, proved to be the most reliable process for atmospherically sintering these large transparent PLZT ceramics.[31]

In another related PLZT work, contributing to a better understanding of these ceramics, the low-temperature phase relations were determined as a function of lanthanum content and temperature. Dielectric and piezoelectric measurements and X-ray data were used to locate and identify the critical phase transitions.[32] Laser-induced Raman spectra of pure powder and multidomain single crystals of lead zirconate, a component used in PLZT body synthesis, was added to the literature. These spectra, previously unavailable, should lead to more efficient PLZT synthesis.[33]

The fracture toughness of a partially stabilized ZrO_2 (PSZ) in the system CaO-ZrO_2 was studied to determine the mechanisms of crack propagation.[34] PSZ ceramics in the system CaO-ZrO_2 are superior to conventionally prepared fully stabilized zirconia in thermal-shock properties. Solid solutions of ZrO_2 and Y_2O_3, prepared by decomposing coprecipitates, were adversely affected by atmospheric CO_2. The atmospheric CO_2 reportedly forms a carbonate complex during preparation which is only partially driven-off during sintering.[35] The remaining CO_2 stabilizes an amorphous phase which encourages crystal nucleation and growth during sintering for oxygen potential probes.

Phase transformation of monoclinic ZrO_2 single crystals, prepared by flux and hydrothermal methods, were studied primarily by DTA. A histogram plot of the transformation temperatures determined from heating and cooling experiments from approximately 60 single crystals revealed two distinct temperature ranges. The transformation temperatures on heating were in the range 1,160° to 1,190° ± 3° C and on cooling, 1,070° to 1,100° ± 3° C.[36] A new binary conducting phase, $Ce_2Zr_3O_{10}$, was discovered in the system CeO_2-ZrO_2.[37] Cerium zirconates are prime candidates as MHD electrodes because of their resistance to alkali attack at elevated temperatures in air.

The pseudobinary Ti-ZrO_2 system was investigated by metallographic, X-ray diffraction, electron probe, and melting-point techniques. This investigation revealed a

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[28] Foundry. Refractory Practice for Coreless Induction Melting-Iron. V. 101, No. 4, April 1973, pp. 56–59.

[29] Palfreyman, M. Canadian Minerals for Refractories. Bull. Can. Min. Met. (CIM), August 1973, pp. 65–73.

[30] Erneta, M., and H. A. Stöckler. Light Scattering by Pores in Ceramics (Pb, La) (ZrTi) O_3. J. Am. Ceram. Soc., v. 56, No. 7, July 1973, pp. 394–395.

[31] Snow, G. S. Improvements in Atmosphere Sintering of Transparent PLZT Ceramics. J. Am. Ceram. Soc., v. 56, No. 9, September 1973, pp. 479–485.

[32] O'Bryan, Jr., H. M. Phase Relations in (Pb, La) $Zr_{0.65}$ $Ti_{0.35}$ 0_3. J. Am. Ceram. Soc., v. 56, No. 7, July 1973, pp. 385–388.

[33] Pasto, A. E., and R. A. Condrate, Sr. Raman Spectrum of $PbZrO_3$. J. Am. Ceram. Soc., v. 56, No. 8, August 1973, pp. 436–438.

[34] Green, D. J., P. S. Nicholson, and J. D. Embury. Fracture Toughness of a Partially Stabilized ZrO_2 in the System CaO-ZrO_2. J. Am. Ceram. Soc., v. 56, No. 12, December 1973, pp. 619–623.

[35] Thompson, M. A., D. R. Young, and E. R. Mc Cartney. Influence of Precipitating Atmosphere on Sintering of ZrO_2 + 12 Mol % Y_2O_3. J. Am. Ceram. Soc., v. 56, No. 12, December 1973, pp. 648–654.

[36] Mitsuhashi, T., and Y. Fujiki. Phase Transformation of Monoclinic ZrO_2 Single Crystals. J. Am. Ceram. Soc., v. 56, No. 9, September 1973, p. 493.

[37] Longo, V., and D. Minichelli. X-Ray Characterization of $Ce_2Zr_3O_{10}$. J. Am. Ceram. Soc., v. 56, No. 11, November 1973, p. 600.

similarity to the $Zr-ZO_2$ system and also presented the phase relations in the $Ti-ZrO_2$ section between 600° and 2,000° C.[38] Phase relations were also proposed for the HfO_2-rich portion of the system $Hf-HfO_2$.[39] Phases in the $Ti-ZrO_2$ and $Hf-HfO_2$ systems are potentially valuable as refractory cermets. Zirania, a new family of zirconium oxide titanium ceramics, was recently developed by United Technology Research, Inc., Hauppauge, N.Y. Zirania, developed for the U.S. Air Force, reportedly can withstand repeated intensive shock at temperatures to 4,000° F without melting or cracking.[40] Zirania may be the answer for a high-temperature substrate to support the platinum or palladium catalysts in automobile catalytic convertors.

The AMAX Zr–Hf Newsletter listed approximately 900 reference abstracts devoted to zirconium and hafnium technology in 1973. Many of these articles were devoted to the use of zirconium and hafnium as metal alone, in alloys and as alloying elements, not only in nuclear applications but also in refractory and oxidation- and corrosion-resistance technology.

AMAX Specialty Metals and Titanium Metals Corp., in a joint effort, succeeded in producing high-purity electrolytic zirconium in a prototype production-size cell. Tests were currently underway on converted wrought shapes for comparison with Kroll-process zirconium.[41]

The major domestic and foreign nuclear fuel fabricators and zirconium metal suppliers participated in a Symposium on Zirconium in Nuclear Application sponsored by the American Society for Testing and Materials, Portland, Oreg., August 21 to 24, 1973. The participants reviewed zircaloy testing methods and procedures and concluded that zircaloy continued to be superior to any other material for the cladding of nuclear fuel in the water-moderated nuclear reactors.

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[38] Domagala, R. F., S. R. Lyon, and R. Ruh. The Pseudobinary $Ti-ZrO_2$. J. Am. Ceram. Soc., v. 56, No. 11, November 1973, pp. 584–587.

[39] Ruh, R., and V. A. Patel. Proposed Relations in the HfO_2-Rich Portion of the System $Hf-HfO_2$. J. Am. Ceram. Soc., v. 56, No. 11, November 1973, pp. 606–607.

[40] Research Development. V. 24, No. 9, September 1973, pp. 18–19.

[41] AMAX Specialty Metals Corporation, Metals Division, Akron, N.Y. Zr–Hf Newsletter. September 1973, 18 pp.

Minor Metals

By Staff, Division of Nonferrous Metals—Mineral Supply

CONTENTS

ARSENIC [1]

Domestic Production.—Arsenic trioxide was produced in the United States solely as a byproduct of base-metal ores, primarily copper ore, and only at the Tacoma, Wash., plant of the American Smelting and Refining Company. Production figures cannot be published but output was only slightly below that in 1972. Shipments exceeded production and yearend stocks were substantially below yearend 1972 inventories.

Consumption and Uses.—Apparent consumption of arsenic, essentially all as white arsenic (As_2O_3), increased 29% over that in 1972. Calcium and lead arsenate were the major end products; minor quantities of arsenic were used in sodium arsenate and other chemical compounds. About 3% of the arsenic consumed was used as metal for alloying with lead and copper. Small quantities of high-purity arsenic were used in the manufacture of gallium and indium arsenides for semiconductors.

Arsenic was used primarily for its toxic qualities in the agricultural industry for insecticides, selective plant killers, defoliants, and for parasitic control in chicken feed. Under the cattle fever tick eradication program, 240,000 cattle were dipped in a 0.22% arsenious oxide solution prior to entry into the United States.

Wood preservation continued as an important use for arsenical compounds. Consumption of chromated copper arsenate (CCA compounds) has grown from 1,165 tons in 1967 to 4,874 tons in 1972. Chromated copper arsenate solutions were used to treat more than 35% of the lumber and timbers treated in 1972. The use of fluor chrome arsenate phenol (Wolman salts and osmosalts) has dropped from 2,671 tons in 1967 to 957 tons in 1972. Until 1969, Wolman salts was the principal wood preservative.

Prices.—The price of refined white arsenic, 99.5%, at New York docks, in barrels, small lots, has been unchanged at 6¼ to 6¾ cents per pound since July 6, 1968. This quotation held through March 8, 1973; thereafter, quotations were listed as nominal. Refined white arsenic in bulk carload lots at Laredo, Tex., was $120 per ton, and crude white arsenic was quoted at $94 per ton at Tacoma, Wash. Lead arsenate in 50-pound bags was quoted at 26 to 29 cents per pound throughout 1973.

Arsenic metal was quoted in London at £690 per metric ton (75.1 cents per pound) until January 18 when it rose to £800 per metric ton (87.1 cents per pound). On June 21 the price was quoted at a range of £800 to £1,000 per metric ton (87.1 to 108.9 cents per pound) where it remained through yearend.

Foreign Trade.—No exports of arsenic metal or white arsenic were reported.

Imports of white arsenic decreased for the third successive year. Receipts were

[1] Prepared by Gertrude N. Greenspoon, mineral specialist.

16% below those in 1972 and the lowest since 1958. Mexico was the chief supplier with 49% of the total imports, followed by Sweden with 36% and France with 11%.

Sweden supplied 590 tons of the 643 tons of arsenic metal imported in 1973. The United Kingdom and Belgium-Luxembourg furnished 20 tons each. The remainder came from Canada, West Germany, Japan, and the Netherlands.

Tariff.—Arsenic oxide (white arsenic) enters the United States duty free. A 1.2-cent-per-pound duty was applicable to arsenic metal.

World Review.—*Philippines.*—Shipments of high arsenic-bearing copper concentrate by Lepanto Consolidated Mining Co. to the Tacoma, Wash., smelter were reduced from 7,000 to 4,500 tons per month because of antipollution curbs placed on the

Table 1.—U.S. imports for consumption of white arsenic (As_2O_3) content, by country

Country	1971		1972		1973	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
Australia	--	--	--	--	21	$3
Belgium-Luxembourg	25	$9	1	$7	--	--
France	1,425	180	1,556	184	1,281	190
Germany, West	(1)	(1)	11	4	11	4
Mexico	8,316	980	3,552	462	5,605	760
Peru	68	27	24	27	25	1
South Africa, Republic of	196	23	285	44	409	50
Sweden	7,276	968	8,184	1,228	4,144	706
Total	17,306	2,187	13,613	1,956	11,496	1,714

[1] Less than ½ unit.

Table 2.—U.S. imports for consumption of arsenicals, by class

Class	1971		1972		1973	
	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)	Quantity (short tons)	Value (thousands)
White arsenic (As_2O_3)	17,306	$2,187	13,613	$1,956	11,496	$1,714
Metallic arsenic	536	1,260	665	1,790	643	2,630
Sulfide	--	--	1	(1)	2	414
Sodium arsenate	124	35	240	69	263	74
Lead arsenate	2	1	--	--	--	--
Arsenic compounds, n.e.c.	(1)	26	(1)	19	(1)	21

[1] Less than ½ unit.

Table 3.—White arsenic (arsenic trioxide) [1]: World production, by country

(Short tons)

Country [2]	1971	1972	1973 p
Brazil	163	181	76
Canada	50	30	--
France	8,844	r e 10,000	10,000
Germany, West	40	491	e 520
Japan	1,054	471	e 500
Mexico	12,658	5,618	4,828
Peru	723	1,123	e 1,200
Portugal	205	15	22
South West Africa, Territory of [3]	[4] 4,080	2,612	8,981
Sweden	19,290	17,857	e 18,200
U.S.S.R. e	7,880	7,940	7,990
United States	W	W	W
Total	r 54,987	46,338	52,317

e Estimate. p Preliminary. r Revised. W Withheld to avoid disclosing individual company confidential data.

[1] Including calculated trioxide equivalent for output reported as elemental arsenic and arsenic compounds other than trioxide.

[2] In addition to the countries listed, Argentina, Austria, Belgium, the People's Republic of China, Czechoslovakia, East Germany, Finland, Hungary, Southern Rhodesia, the United Kingdom, and Yugoslavia have produced arsenic and/or arsenic compounds in previous years, but information is inadequate to ascertain whether such output has continued, and if so at what levels.

[3] Output of Tsumeb Corp. Ltd. only.

[4] Production for year ended June 30, 1971. Output during July 1, 1971, to December 31, 1971, was 2,988 short tons.

smelter. The company was attempting to find an alternate smelter to avoid a 35% production cutback.

Sweden.—Arsenic production rose 2% in 1973. The low output in 1972 resulted from lower arsenic content of the ores and to changes in the refining plant. Production of arsenic metal rose as an additional unit went into operation. The current capacity of 1,500 tons annually for the metal plant can be increased if market conditions warrant expansion.

CESIUM AND RUBIDIUM [2]

Domestic Production.—There was no domestic production of cesium or rubidium ores in 1973. All domestically produced cesium and rubidium compounds were processed from imported pollucite or *ALKARB* (a residue from the processing of lithium ores).

Total production of cesium chemical compounds declined slightly in 1973, whereas the output of rubidium chemical compounds tripled. Cesium and rubidium compounds were produced by Kawecki Berylco Industries, Inc., Revere, Pa.; Kerr-McGee Corp., Trona, Calif.; and Rocky Mountain Research, Inc., Golden, Colo. There was no reported production of cesium or rubidium metal during the year; however, small quantities of cesium and rubidium metals were shipped from stocks.

Consumption and Uses.—Data, relating to the consumption and use pattern of cesium and rubidium metals and compounds, were not available. However, major uses were thought to be in research and development of new power-generating systems, biological sciences, and other technical areas. Cesium and rubidium found commercial application in the manufacture of pharmaceuticals, ultracentrifuge separation of organic compounds, ionic propellant engines for space-flight applications, and electronic apparatus such as scintillation counters, photomultiplier tubes, and photoelectric cells. Cesium, rubidium, and their compounds can be substituted for each other in some end uses.

Any potential for a large-scale increase in the demand for cesium and rubidium continued to be contingent on the commercial development of magnetohydrodynamic (MHD) electric power generators and thermionic converters. The Office of Coal Research, U.S. Department of the Interior, continued to fund MHD research.

Prices.—During the year, the American Metal Market quoted a nominal price for pollucite, containing about 20% Cs, in minimum lots of 10 tons delivered to an entry point, at $300 per short ton. The Metal Bulletin also quoted the nominal price for pollucite concentrates, containing minimum 24% Cs_2O, f.o.b. source, at $11.08 per metric ton unit (22.046 pounds of Cs_2O). The American Metal Market quotation on cesium metal, 99+% purity, remained unchanged at $100 to $375 per pound. The quotation on rubidium metal, 99.5+% purity, also remained unchanged at $300 per pound.

Table 4.—Prices of selected cesium and rubidium compounds

Item	Base price per pound [1] Technical grade	High-purity grade
Cesium bromide	$28	$65
Cesium carbonate	29	67
Cesium chloride	30	68
Cesium fluoride	35	75
Cesium hydroxide	35	75
Rubidium carbonate	45	75
Rubidium chloride	46	76
Rubidium fluoride	51	83
Rubidium hydroxide	51	83

[1] Excludes packaging cost, 50- to 100-pound quantities, f.o.b. Revere, Pa.

Source: Kawecki Berylco Industries, Inc.

Foreign Trade.—Only small quantities of pollucite were imported from Canada during the year, but data on the quantity and value of imports of cesium and rubidium ores were not available. Imports of cesium compounds declined greatly from 12,048 pounds, valued at $330,691 in 1972 to 3,159 pounds, valued at $111,631 in 1973. No rubidium metal was imported during 1973. No other data were available on imports or exports of cesium and rubidium products.

World Review.—During 1973, the Tantalum Mining Corp. of Canada, Ltd., produced about 300 tons of pollucite. Of this

[2] Prepared by Benjamin Petkof, physical scientist.

quantity, 250 tons was shipped to the U.S.S.R.

Although Southern Rhodesia has not officially reported pollucite production since its independence in 1966, the Bikita Minerals Ltd. Mining Lease No. 1, near Glen Cova in the Victoria District was listed as an operating mine as of January 1, 1973, and presumably remained in operation throughout the year.

No information was available on the 1973 status of the mining properties in the Karibib area of the Territory of South West Africa, which were in operation through 1967, the last year for which official data were published.

Table 5.—U.S. imports for consumption of cesium compounds, by country

Country	Cesium chloride		Cesium compounds, n.s.p.f.	
	Pounds	Value	Pounds	Value
Germany, West	1,437	$55,246	1,502	$47,409
Netherlands	--	--	48	4,438
United Kingdom	110	3,035	62	1,503
Total	1,547	58,281	1,612	53,350

GERMANIUM[3]

Domestic production and consumption of germanium in 1973 was little changed from that of the last 3 years with the use of germanium in optics increasing to where it nearly equals that used in semiconductors.

Legislation and Government Programs.—On June 26, 1973, the Tariff Commission received advice from the Treasury Department that germanium point contact diodes from Japan were being or were likely to be sold at less than fair market value within the meaning of the Antidumping Act of 1921. Accordingly, the Commission instituted an investigation. A public hearing was held August 10, 1973, and on the basis of evidence supplied to the Commission, it concluded that a domestic industry was not being injured by reasons of importation of germanium point contact diodes from Japan at less than fair market value.

Domestic Production.—Production of germanium from domestic sources was estimated at 27,000 pounds in 1973, with an additional 10,000 pounds recovered from germanium-containing zinc concentrates imported from other countries. No new residues were recovered from the treatment of ores from the Kansas-Missouri-Oklahoma zinc-bearing region, most of the germanium was obtained from such smelter residues that had been stockpiled. Primary production is supplemented by recycled waste or new scrap, which returns from 65% to 80% of that metal used in semiconductors.

All the primary germanium was produced by Eagle-Picher Industries, Inc., from stockpiled zinc smelter residues at its Quapaw, Okla. plant. Eagle-Picher also reprocessed new scrap. Other producers of secondary germanium were GTE Sylvania, Inc., Towanda, Pa.; Kawecki Berylco Industries, Revere, Pa.; and Atomergic Chemetals Co., Long Island, N.Y.

Consumption and Uses.—Apart from germanium's specialized uses in the realm of transistors and solid state physics, germanium has important applications in metallurgy, chemotherapy, polymer chemistry, and optical instrumentation. Since germanium-containing glass has a high refractive index, it finds use in wide-angle camera lenses and microscope objectives. Other uses are for making special glasses for spectroscopes and infrared devices, in high-temperature technology as a stabilizer for zirconium against phase changes, and in the fabrication of fuel elements in atomic reactors. Semiconductors and optics account for approximately 90% of the domestic use of germanium.

There is currently a great deal of interest in organogermanium compounds as polymers and therapeutic agents. Certain of these compounds have been found to have marked antimicrobial activity combined with low mammalian toxicity. Of greater interest is the possible use of germanium compounds for treating carcinoma and leukemia.[4]

[3] Prepared by Herbert R. Babitzke, physical scientist.

[4] Bannerjee, N. N., H. S. Rao, and A. Lahiri. Germanium in Indian Coals. Quarterly Bulletin of the Central Fuel Research Institute, India. V. 23, Nos. 1-2, March-June 1973, pp. 24-26.

Medicines containing carboxyethylgermanium sesquioxide have been developed for domestic animals. The organic germanium medicines are effective in curing and preventing various animal diseases caused by viruses, bacteria, and protozoans.[5]

A new medicinal toothpaste containing GeO_2 was highly effective for control of periodontopathia. Gingivostomatitis was cured 4 months after application of the prepared toothpaste.[6]

Research and development is continuing in the use of platinum-germanium catalysts. Gasoline is reformed with hydrogen over a bimetallic catalyst with continuous halogen additions. The catalyst is platinum metal and a germanium compound on a porous carrier.[7]

Superconductors continued to receive researchers' attention. Investigations have revealed that niobium-germanium films remain superconducting up to 22.3° K. The high critical temperature of the films was attributed to the formation of a more nearly perfect stoichiometric Nb_3Ge compound that had not been attained before.[8]

New diamondlike semiconductor materials have been developed that show promise for infrared, nonlinear optical and electroluminescent applications. One of the ternary materials, $ZnGeP_2$, has the potential to emit light at the proper wavelength, which makes it important to the field of optical communications.[9]

The Bureau of Mines has employed handheld scanners in investigations to detect abnormal surface temperatures on dumps of flood-generated trash near Wilkes-Barre, Pa.[10], and in coal mines to detect failure in roof and ribs of an underground opening.[11] The scanner, which was originally developed for military use as a night vision device, has a lens configuration consisting of two germanium components and one silicon component. The operator views a thermal image of the target area in which the contrast in the image is proportional to the magnitude of the temperature differences on the target. In a normal operation mode, hot areas are bright in the image.

Table 6.—U.S. imports for consumption of germanium, by country

Country	Quantity (pounds)	Value
Unwrought and waste and scrap:		
Belgium-Luxembourg	1,995	$674,351
Czechoslovakia	110	5,750
Denmark	160	10,002
Germany, West	4,206	226,603
U.S.S.R.	7,696	449,532
United Kingdom	538	32,509
Total	14,705	1,398,747

Prices.—The prices of domestic zone refined (intrinsic) germanium and domestic germanium dioxide remained at $293 and $167.50 per kilogram, respectively, through 1973. These prices have been in effect since June 8, 1970. The selling price of imported germanium metal and germanium dioxide was increased by about 13% to reflect the devaluation of the dollar. The increases, effective February 14, 1973, brought the price of germanium metal to $260 per kilogram from $229 and germanium dioxide to $136 per kilogram from $120.

Foreign Trade.—U.S. imports of germanium metal (unwrought and waste and scrap) was 14,705 pounds valued at $1,398,747 in 1973, nearly a threefold increase in quantity and a twofold increase in value over 1972 imports. The U.S.S.R. supplied 52% of the germanium imports, West Germany supplied 29%, and Belgium-Luxembourg supplied 14%.

World Review.—World production of primary germanium was estimated at 165,000 pounds in 1973.

[5] Yasutoshi, T. Medicines Containing Carboxyethylgermanium Sesquioxide for Animals. Japanese Pat. 73 16,167, May 19, 1973, 4 pp.

[6] Shigato, T., and N. Kiyoshi. Dentrifrices for Control of Periodontopathia. Japanese Pat. 73 52,949, July 25, 1973, 5 pp.

[7] Hayes, John C. Catalytic Reforming with a Catalyst and with Halogen Addition. U.S. Pat. 3,745,111, July 10, 1973.

[8] Gavaler, J. R. Superconductivity in Niobium Germanium Films Above 22° K. Appl. Physics Letters, v. 23, No. 8, 1973, pp. 480–482.

[9] Metal Progress. Optical Applications Envisioned for Ternary Semiconductor. V. 105, No. 1, January 1974, p. 50.

[10] Stateham, R. M. Detecting Hot Areas in Dumps With a Handheld, Infrared Scanner. BuMines TPR 68, 1973, 12 pp.

[11] Stateham, R. M. Field Studies on an Unsupported Roof, York Canyon Coal Mine, Raton, N. Mex. BuMines R.I. 7886, 1974, 18 pp.

INDIUM [12]

Domestic Production.—The only domestic production of primary indium metal reported during the year was by the American Smelting and Refining Company (Asarco) at its Denver, Colo., and Perth Amboy, N.J., plants. Other companies processed or refined imported material and domestic stocks to produce high-purity metal components, alloys, and compounds. Domestic production of indium is a small fraction of U.S. consumption.

Uses.—The pattern of indium usage was estimated to be divided among several industries: 25% in solders and low-melting-point alloys, 20% in forming junctions with semiconductors and other electronic components, 20% in bearing alloys to increase hardness and resist corrosion, 10% in lamps and other optical devices, 12% in silver alloys used in atomic reactor control rods, 13% for research and other uses.

Stocks.—Producer stocks are estimated to have decreased considerably from those held several years ago.

Prices.—Indium pricing is based on the standard-grade metal (99.97% pure): higher purity grades (99.999% plus) are available at a premium. In 1972 and earlier years, sticks in lots of less than 100 ounces and ingots of 100 ounces were quoted at prices above the base price, but since December 1972, the only producer quotation published in Metals Week has been for ingots in lots of 10,000 ounces or more. Throughout the year, to December 10, 1973, this quotation was $1.75 per ounce. Asarco raised the price to $2 per ounce on December 10, after the Cost of Living Council had released most nonferrous metals from price controls.

During 1973, indium of Soviet origin was apparently withdrawn from the European market, and prices that had been considerably below the U.S. producer price began to approach this price as a tighter supply situation developed.

Foreign Trade.—Imports of indium continued to increase, rising 29% over 1972 imports to 811,527 troy ounces. The main sources of imports were Canada (41%), U. S. S. R. (14%), Belgium-Luxembourg (13%), and the United Kingdom (12%).

The duty effective in 1973 on unwrought and waste and scrap indium was 5% ad valorem and on wrought indium was 9% ad valorem for most favored nations. Duties on waste and scrap were suspended until June 30, 1975. The statutory duty for the Soviet Union was 25% ad valorem on unwrought indium and 45% ad valorem on wrought metal.

Table 7.—U.S. imports for consumption of indium, by country

Country	Quantity (troy ounces)	Value
Unwrought and waste and scrap:		
Belgium-Luxembourg	104,796	$54,164
Canada	333,231	377,240
Germany, West	3,084	4,406
Japan	6,412	7,301
Netherlands	59,572	75,012
Peru	87,089	145,064
Switzerland	58	1,322
U.S.S.R.	115,164	110,650
United Kingdom	95,691	198,658
Total	805,097	973,817
Wrought:		
Netherlands	6,410	9,171
Switzerland	12	1,905
United Kingdom	8	1,109
Total	6,430	12,185

Technology.—Researchers in England investigated the photoluminescence of indium phosphide in light-emitting diodes and results were published in a trilogy of papers.[13] The use of indium-111 in radionuclides to diagnose and possibly to treat tumors was described.[14] The thermodynamic properties of indium in low-melting alloy systems was investigated at United States and Indian universities.[15]

[12] Prepared by J. M. Hague, mining engineer.

[13] Williams, E. W., W. Elder, M. G. Astles, M. Webb, J. B. Mullin, B. Straughan, and P. J. Tufton. Indium Phosphide. Parts 1, 2, and 3, J. Electrochem. Soc., v. 120, No. 12, pp. 1741–1760.

[14] Chemical and Engineering News. Indium Radionuclide Helps Detect Cancers. V. 51, No. 14, Apr. 2, 1973, pp. 12–13.

[15] Masson, D. B., and S. S. Pradhan. Measurement of Vapor Pressure of Indium Over α Ag-In Using Atomic Absorption. Met. Trans., v. 4, No. 4, April 1973, pp. 991–995.

Servis, H. J., and Z. A. Munir. Thermodynamic Properties of Liquid Indium-Cadmium Alloys. J. Less-Common Metals, v. 34, No. 2, February 1974, pp. 293–299.

Singh, H. P., and S. Misra. On the Thermodynamic Properties of the Mercury-Indium System. J. Less-Common Metals, v. 32, No. 2, August 1973, pp. 227–235.

RADIUM [16]

A downtrend in the use of radium continued during 1973. Radium was used primarily in therapeutic treatment of cancer. In medical and industrial applications, radium was more frequently replaced by cheaper and less hazardous radioisotopes.

Domestic Production.—There was no production of radium in the United States during the year. The small domestic demand was met by imports or withdrawals from dealers' stocks. Radium Chemical Co., Inc., New York, was the main dealer in the United States.

Consumption and Uses.—Radium, in small quantities expressed in milligrams, was used in treatment of cancer and in luminous compounds, static eliminators, and neutron sources. Based on manufacturers' sales data, about 1,300 to 1,600 curies of radium have been sold in the United States through 1973. Approximately 330 to 360 curies, contained in 50,000 to 60,000 sources, were in use in medical applications during 1973. Nonmedical uses accounted for 250 curies, and the rest was involved in luminous compounds and other uses.[17]

Several curies are added annually to the total radium in use in the United States. The aftereffects of gamma radiation in medical applications and the price of radium have lead to substitution by other radioisotopes. This trend was also apparent in other uses of radium.

Prices.—Radium prices, per milligram, were quoted by Radium Chemical Co., as follows: Less than 100 milligrams, $24; 200 to 499 milligrams, $20; 500 milligrams to 4.99 grams, $18; over 5 grams, $17.

Foreign Trade.—Data on trade in radium was not published; in most cases, the radium data was included with that for other items in trade statistics. Belgium remained the principal source of radium imported into the United States.

World Review.—Information on radium in world markets was not readily available. The Belgian company, Union Minière S.A., was the largest radium producer and supplier in the noncommunist world. In addition, small quantities of radium were apparently produced in Canada and the United Kingdom. Czechoslovakia, with its long tradition in uranium mining, and the U.S.S.R. probably also produced some radium. Throughout the world, uses of radium were similar to those in the United States.

Technology.—The Federal Bureau of Mines, Salt Lake Metallurgy Research Center, Salt Lake City, Utah, completed a study to develop techniques for recovering radium from uranium ores, tailings, and processing solutions to eliminate this radioactive contaminant.

The U.S. Atomic Energy Commission sponsored a research program studying the distribution of radium and 13 other metallic elements. This distribution was quantitatively compared by distributing a radiotracer of the element of interest between an aqueous phase and an organic phase. From the ratio of activity in the organic phase to activity in the aqueous phase, distribution coefficients were calculated as function of pH.[18]

SCANDIUM [19]

Research activities led to a few new industrial applications for scandium, although only small quantities of scandium were involved. The small domestic supply of scandium was provided by one producer of the metal and oxide, which were derived from imported raw materials. Supply was adequate to meet demand.

Domestic Production.—There was no scandium mine production in the United States during 1973. The small output of scandium metal, measured in a few tens of pounds and derived from imported raw materials, was at approximately the same level as in 1972. Research Chemicals, a division of Nucor Corp., Phoenix, Ariz., remained the only domestic producer.

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[16] Prepared by Roman V. Sondermayer, physical scientist.

[17] Data on uses are estimates based on partial sales reports.

[18] Jackson, W. M., and G. I. Gleason. Distribution Studies of Radium and Other Metallic Elements Between Thenoyltrifluoracetone in Methyl Isobutyl Ketone and Aqueous Solution. Anal. Chem., v. 45, No. 12, October 1973, pp. 2125–2129.

[19] Prepared by Roman V. Sondermayer, physical scientist.

Consumption and Uses.—Scandium was used in research and in a few industrial applications. Research was aimed at better understanding the properties and behavior of scandium in different environments. Researchers studied scandium radioisotopes and investigated alloying, electrical, and chemical properties of the metal, compounds, and products.

The main industrial applications of scandium were in high-intensity lamps for lighting outdoor events to be televised in color and in radioactive tracers for controlling flow of underground fluids in petroleum production. Small quantities of scandium were also consumed in magnesium alloys and in the electronics and chemical industries.

Prices.—The price of scandium oxide, 99.9% Sc_2O_3, as quoted by Research Chemicals, remained unchanged from that of 1972 at $2.80 per gram in lots of 100 to 453 grams; the price of scandium metal in ingots and distilled grades was $8 and $15 per gram, respectively; whereas that of powder and chips remained unchanged at $10.35 per gram. Prices for scandium sheet foil were $17.85 to $105 per square inch for 51- to 100-square-inch lots, ranging from 0.001 to 0.1 inch in thickness. For most items, larger quantities were available at lower prices.

Foreign Trade.—Official U.S. foreign trade statistics did not report trade in scandium as such but included scandium with other minerals and metals. However, based on available information, Australia and the Communist countries, probably the U.S.S.R., were the principal suppliers of scandium-bearing raw materials.

World Review.—Information on scandium-related activities in foreign countries was not readily available. The industrialized nations were involved in scandium research and used small quantities of scandium in industrial applications.

Technology.—A magnetically controlled switch, which can modulate light, was developed in Bell Laboratories. The switch consists of a thin film of single-crystal yttrium-gallium-scandium iron garnet, a small electric circuit, and two prisms that guide the light beam into and out of the garnet. Electric current creates a magnetic field, which causes the light beam to change its polarization and direction. Development of the new light switch permits use of laser beams instead of wire conductors, coaxial cables, and microwaves in future communication systems.[20]

Because of good hydrogen absorption properties of scandium, a new scandium detector was developed for use with a gas chromatograph. The device can operate at temperatures up to 325° F. The new detector has successfully analyzed residues of pesticides in samples of vegetable crops at the 0.1-part-per-million level.[21]

Scientists of the Australian Atomic Energy Commission at Lucas Heights, New South Wales, developed an instrument that employs gamma radiation from radioactive scandium oxide tracers to measure the density of wood and locate termite colonies. Termites were fed with the radioactive tracer, which was later excreted and used to build nest walls. A portable Geiger counter would locate these nests by indicating areas of anomalous radioactivity.[22]

SELENIUM[23]

Domestic production of selenium from primary materials was 627,000 pounds in 1973, a 15% decrease from 1972 production. Shipments by domestic producers decreased 10% with the difference supplied by stocks, which were reduced 55,000 pounds to 106,000 pounds at yearend. World production decreased 9% to 2,458,000 pounds. Congress authorized disposal of selenium held in the national stockpile on August 11, 1971, and during 1971 and 1972 a total of 16,090 pounds of metal was sold or traded. During 1973 a total of 329,790 pounds of selenium was sold or exchanged for strategic commodities needed for the national stockpile. At the end of 1973, the national stockpile contained 128,894 pounds of uncommitted selenium.

[20] Institute for Atomic Research, Iowa State University, Ames, Iowa. Garnet Switch Modulates Light. Rare Earth Information Center News, v. 8, No. 1, Mar. 1, 1973, p. 4.
[21] Institute for Atomic Research, Iowa State University, Ames, Iowa. Sc^3H Detector. Rare Earth Information Center News, v. 8, No. 2, June 1, 1973, p. 2.
[22] Industrial Week. Emerging Technologies. V. 114, No. 1, January 1974, p. 23.
[23] Prepared by Lyman Moore, mining engineer.

Table 8.—Salient selenium statistics

(Thousand pounds of contained selenium)

	1969	1970	1971	1972	1973
United States:					
Production	1,247	1,005	657	[1] 739	[1] 627
Shipments to consumers	1,429	1,056	663	[1] 761	[1] 682
Imports for consumption	546	454	395	430	553
Stocks, Dec. 31, producers	240	189	182	161	106
Producers average price per pound commercial and high-purity grades	\$7–\$8.50	\$9–\$10.50	\$9–\$11.50	\$9–\$11.50	\$9.25–\$12.36
World: Production	2,834	2,883	2,506	2,687	2,458

[1] In addition, an estimated 30,000 pounds of selenium was refined from secondary sources.

Domestic Production.—Primary selenium was produced at four plants operated by the following major electrolytic copper refiners: American Metal Climax, Inc., Carteret, N.J.; American Smelting and Refining Company, Baltimore, Md.; The Anaconda Company, Perth Amboy, N.J.; and Kennecott Copper Corp., Garfield, Utah. Crude materials containing primary selenium were transferred to these plants from copper refineries operated by Inspiration Consolidated Copper Co., Magma Copper Co., and Phelps Dodge Corp. An estimated 30,000 pounds of selenium was recovered by domestic secondary refineries from purchased electronic scrap. Considerable selenium home scrap was reused by manufacturers after outside reprocessing under toll contracts. Some domestic selenium-containing material was shipped to foreign plants for refining. High-purity selenium and various selenium compounds were produced by primary and other processors from commercial-grade metal.

In September the American Smelting and Refining Company began constructing a 420,000-ton-per-year electrolytic copper refinery near Amarillo, Tex., that will eventually replace a plant of 312,000-ton capacity at Baltimore, Md. The new, larger plant will recover byproducts, including selenium, and its completion will increase domestic selenium production capacity.

Consumption and Uses.—Apparent selenium supply and consumption, consisting of producer shipments, net imports, and stockpile releases, increased about 34% over that in 1972. Selenium demand, as indicated by dealer prices, increased moderately during the first 10 months of the year and increased sharply in November and December. Most of the increased use occurred in electronic applications. Major uses were electronic components, 45%; ceramics and glass, 34%; chemicals, 13%; and other, 8%.

Consumption of selenium in xerography increased during 1973, and this use now consumes over one-fourth of the primary metal shipped. More efficient use of selenium in xerographic copying machines and reclaiming of home scrap have kept the consumption of primary selenium in xerography from increasing as fast as the use of xerographic copying machines. However, new applications in this field promise a larger future demand. Selenium consumption for rectifiers, photoelectric cells, and other electronic applications increased, although more slowly than industrial production of these items owing to more efficient use of selenium. These uses consumed about one-fifth of the selenium marketed. Use of selenium in glass manufacturing increased because of increased glass production.

Small proportions of selenium compounds are added to glass melts to neutralize the green coloration caused by iron. Larger proportions are used to produce gray and bronze tinted window glass that reduces glare and heat transmission and to produce red- and amber-colored glass for signals and decorative uses. Demand for selenium in pigments and steel alloys increased significantly. Other chemical, pharmaceutical, and miscellaneous uses increased slightly over those in 1972.

Prices.—The producers' price remained at \$9 per pound for commercial-grade selenium and \$11.50 per pound for high-purity metal from the start of 1973 until April 2 when one producer increased the price of each metal grade by \$1 per pound. Other producers did not change their price, and the split quotation continued until June and was then frozen by the Cost of Living Council. Selenium prices were decontrolled on December 10, and domestic producers increased their prices to \$11 and \$12 per pound for commercial grade and $14 per pound for high-purity grade and continued these quotations to the end of the year.

Domestic dealer prices of commercial-grade selenium were about $8.40 per pound at the start of 1973. The average price received at Government stockpile sales was $8.50 per pound on February 14; $9.10 per pound on June 25; $9.68 per pound on August 27; and $12.88 per pound on November 15. At the end of December, dealer selenium prices were $17 to $17.50 per pound for commercial-grade metal.

Canadian producers priced commercial-grade selenium at $9 per pound from January to late March, at $10 per pound from late March to late October, and at $11 per pound for the remainder of the year. European dealer prices for the commercial grade increased from $9 to $10 per pound during the first half of the year, increased further to $11.50 per pound in late September, and to $17.50 per pound in late October, with this price continuing the remainder of the year.

In August principal European metal dealers formed the Minor Metals Traders Association, open to dealers in minor metals including selenium. The association plans to set up standard sales contracts for minor metals and possibly establish a minor metal trading ring and arbitration panel.

Foreign Trade.—Selenium exports increased about 20% from those of 1972; the largest shipments were made to West Germany, the Netherlands, and the United Kingdom.

Selenium imports for consumption increased 29%, and the value of imports increased 32%. Canada continued to be the main supplier.

Table 9.—U.S. imports for consumption of selenium, by country

(Thousand pounds and thousand dollars)

Country	Quantity	Value
Unwrought and waste and scrap:		
Canada	476	4,759
Chile	8	73
Ireland	(1)	3
Japan	16	150
Mexico	10	76
Sweden	(1)	1
Total	510	5,062
Oxide (selenium content):		
Canada	40	525
United Kingdom	3	31
Total	43	556

[1] Less than ½ unit.

World Review.—World refinery production is shown in table 10. Japan was the leading selenium producer, U.S. was second, and Canada was third. These three countries accounted for 82% of world production (excluding the U.S.S.R.).

Zambia.—Sludges and slimes from electrolytic copper refineries are treated outside Zambia for recovery of selenium and other byproducts. In 1973, plans were made to build a plant in Zambia to recover the byproducts. The plant will be located near the Ndola Copper Refinery and is expected to be operational in 1976.

Technology.—The Selenium-Tellurium Development Association, Inc., continued sponsorship of research programs designed to increase selenium utilization.

On April 27, 1973, the Food and Drug Administration (FDA) proposed that animal feed regulations should be amended to allow the addition of selenium as a nutrient in the feed of chickens, turkeys, and swine. The FDA set the minimum dietary requirement for available selenium in feed at 0.1 part per million (ppm) for swine and for chickens up to 16 weeks in age, and at 0.2 part per million for turkeys. A dietary intake of less than these amounts may result in a variety of debilitating, or even fatal, afflictions such as exudative diathesis, and degeneration of organs and musculature. The selenium content of corn grown in the Midwestern States varies from 0.01 to 2.03 parts per million selenium with the median being 0.05 part per million. Thus the addition of selenium is desirable to feed grown in most States. Studies made for the FDA established that the addition of the recommended quantities of selenium to animal and poultry feed would not cause a significant increase in the selenium content of animal tissue consumed by humans. The present human dietary intake of selenium in the United States was shown to be adequate for good nutrition and safely below the toxic level for selenium ingestion.[24]

[24] Food and Drug Administration. Selenium in Animal Feed. Federal Register, v. 38, No. 81, Apr. 27, 1973, pp. 10,458–10,460.

Table 10.—Selenium: World refinery production, by country [1]

(Thousand pounds)

Country [2]	1971	1972	1973 p
Australia e	7	7	8
Belgium-Luxembourg [3]	r 121	147	e 106
Canada	886	720	[4] 598
Finland	14	11	e 12
Japan	524	738	789
Mexico	115	97	86
Peru	16	18	e 18
Sweden	112	r e 120	e 120
United States	657	739	627
Yugoslavia	54	90	e 94
Total	r 2,506	2,687	2,458

e Estimate. p Preliminary. r Revised.

[1] Insofar as possible, data relate to refinery output of elemental selenium only; thus countries that produce selenium in copper ores and concentrates, blister copper, and/or refinery residues but do not recover elemental selenium have been excluded to avoid double counting.

[2] In addition to the countries listed, West Germany and the U.S.S.R. are known to produce refined selenium, and Zaire and Zambia may produce refined selenium, but available information is inadequate to make reliable estimates of output levels.

[3] Exports.

[4] Recoverable selenium content of blister copper treated at domestic refineries plus refined selenium from domestic raw materials, but excludes other unspecified materials that provide a portion of total refined selenium output. Corresponding figures for previous years in thousand pounds are 1971—719; 1972—655.

Increasing fuel and energy costs resulting from the petroleum shortage stimulated interest in greater use of selenium-tinted window glass to reduce heat-transfer rates. Increasing interest was also shown in direct conversion of sunlight to electricity with photogalvanic cells. A new analytical method was developed at North Carolina State University to rapidly determine small quantities of mercury and selenium in coal and other materials. A new low-energy photodetector is used to improve the neutron activation method. Instrumental errors of less than 0.1 part per million are indicated.[25]

TELLURIUM [26]

Domestic tellurium production of 241,000 pounds in 1973 was 6% below that of 1972. Domestic shipments of 287,000 pounds were the highest on record and were 6% above those of 1972. Producer stocks were drawn down 46,000 pounds to 56,000 pounds, the lowest inventory since before World War II. Imports decreased to a normal 71,000 pounds from the unusually high 1972 receipts.

Domestic Production.—Production of tellurium was reported by the following major electrolytic copper or lead refiners: American Metal Climax, Inc., Carteret, N.J.; American Smelting and Refining Company, Baltimore, Md.; The Anaconda Company, Perth Amboy, N.J.; and United States Smelting Lead Refinery, Inc., East Chicago, Ind., a division of UV Industries, Inc. Electrolytic refinery sludges containing primary tellurium were also produced at refineries operated by Inspiration Consoli-

[25] Weaver, J. N. Determination of Mercury and Selenium in Coal by Neutron Activation Analysis. Anal. Chem., v. 45, No. 11, September 1973, pp. 1950–1952.

[26] Prepared by Lyman Moore, mining engineer.

Table 11.—Salient tellurium statistics

(Thousand pounds of contained tellurium)

	1969	1970	1971	1972	1973
United States:					
Production	234	158	164	257	241
Shipments to consumers	182	209	163	271	287
Stocks, Dec. 31, producers	177	128	116	102	56
Imports	112	64	30	146	71
Price per pound, commercial grade (average)	$6	$6	$6	$6	$6.05
World: Production	395	367	r 320	384	420

r Revised.

dated Copper Co., Kennecott Copper Corp., Magma Copper Co., and Phelps Dodge Corp. High-purity tellurium, tellurium master alloys, and tellurium compounds were produced by primary and intermediate processors from commercial-grade metal and tellurium dioxide.

Production of tellurium was terminated at the United States Smelting Lead Refinery, Inc., during the year because of the exhaustion of unrefined tellurium inventories accumulated during a previous operating period when large quantities of primary lead containing tellurium were refined. Two copper refinery expansions were begun or announced that will result in the future recovery of larger quantities of tellurium-containing electrolytic-copper-refining sludge. Plans were also announced for future byproduct tellurium production from gold telluride deposits in which development has been resumed following the rapid increase in the price of gold.

Consumption and Uses.—Apparent consumption, as indicated by shipments plus imports for consumption, was 358,000 pounds, a reduction of 14% from that in 1972. However, actual consumption probably increased during 1973 with dealer and fabricator inventories being drawn down as were producer inventories. About 65% of tellurium consumed in 1973 was used as a free-machining agent in carbon and stainless steel and as a chilling agent in cast iron. In 1973 carbon steel production increased 20%, stainless steel 22%, and iron and steel castings 12%. Tellurium consumption in iron and steel products showed a similar increase. About 17% of the tellurium consumed was used in free-machining copper. Consumption of copper ingots and ingot bars increased about 3% with about the same increase being made in tellurium usage. Rubber manufacturing consumed about 10% of all tellurium used, chemicals about 6%, and electronic and other uses 2%. Small increases in tellurium consumption were made in these industries.

Prices.—The producer price for commercial-grade powder and slab remained at $6 per pound from 1962 until December 10, 1973, when, following decontrol of tellurium prices by the Cost of Living Council, producers increased their price to $7 per pound and continued this quotation to the end of the year. Merchant prices remained close to producer prices throughout the year. Prices for high-purity grades of tellurium ranged from $10 to $32 per pound.

Foreign Trade.—Imports in 1973 totaled 71,000 pounds, compared with an unusually high import of 146,000 pounds in 1972. The average import during the past 5 years has been 85,000 pounds. Canada and Peru continued to supply nearly all of the U.S. imports.

Table 12.—U.S. imports for consumption of tellurium, by country

(Thousand pounds and thousand dollars)

Country	Quantity	Value
Unwrought and waste and scrap:		
Canada	30	200
Germany, West	(1)	2
Japan	2	8
Netherlands	(1)	1
Peru	38	220
United Kingdom	1	3
Total	71	434

[1] Less than ½ unit.

Table 13.—Tellurium: World refinery production, by country [1]

(Thousand pounds)

Country [2]	1971	1972	1973 p
Canada [3]	r 24	46	45
Japan	79	77	e 94
Peru	53	4	e 40
United States	164	257	241
Total	r 320	384	420

e Estimate. p Preliminary. r Revised.

[1] Insofar as possible data relate to refinery output only, thus countries that produce tellurium in copper ores and concentrates, blister copper, and/or refinery residues but do not recover refined tellurium are excluded to avoid double counting.

[2] In addition to the countries listed, Australia, Belgium, West Germany, and the U.S.S.R. are known to produce refined tellurium, and other countries such as Zaire and Zambia may produce refined tellurium, but available information is inadequate to make reliable estimates of output levels.

[3] Includes recoverable tellurium content of blister copper treated at domestic refineries plus refined tellurium from domestic raw materials, but excludes other unspecified materials that provide a portion of total refined tellurium output.

World Review.—The United States continued to lead the world in tellurium output; Japan was second, and Canada was third.

THALLIUM [27]

Thallium is a highly toxic metallic element that is limited in its use and size of market.

Domestic Production.—Thallium is recovered as a byproduct from flue dust and residue produced in the smelting of base metals, principally zinc. American Smelting and Refining Company Globe Plant at Denver, Colo., was the only domestic producer of thallium and thallium compounds. Production and shipments were nearly the same as those for 1972. Domestic and world identified resources of thallium from zinc, lead, and iron sulfides were 266 tons and 1,390 tons, respectively. Additional U.S. and world resources contained in coal ash are 119,000 and 715,000 tons, respectively.[28]

Uses.—Estimates of world consumption of thallium approximates 30,000 pounds annually. U.S. requirements are about one-fifth of the world requirements.

The current uses of thallium are primarily in electronics and metallurgical processing; minor applications are in glass, agriculture, medicine, and explosives. Some thallium compounds are extremely photosensitive, especially to light of low intensity. This unique property of specific compounds promises new and interesting applications. Uses and demand are limited by the need for comprehensive research into its complete physical and chemical properties and into its potential uses. The highly toxic nature of thallium salts is a deterrent, and substitutes are available for some of its present applications.

Storage batteries with silver thallium iodide solid electrolyte were under investigation in Japan. Mixed crystals of AgI-TlI were prepared. Results after testing indicated very small changes in voltage and current after 8 hours of discharging.[29]

Thallium sulfate, a highly toxic pesticide, is still turning up in the marketplace after 7 years of warning of its dangers. The Environmental Protection Agency requested all retail outlets to surrender all supplies. Continued sale subjects the dealer to civil and criminal penalties.[30]

Prices.—The price of thallium in 25-pound lots has been $7.50 per pound since December 1957.

Foreign Trade.—U.S. imports for consumption in 1973 were 541 pounds of unwrought and waste and scrap thallium valued at $1,730. The amount was only about one-third of that imported in 1972. Thallium compounds imported were 258 pounds valued at $4,030.

[27] Prepared by Herbert R. Babitzke, physical scientist.
[28] Robinson, K. Thallium. Ch. in United States Mineral Resources. U.S. Geol. Survey Prof. Paper 820, 1973, pp. 631–636.
[29] Saito, S. Storage Batteries With Silver Thallium Iodide Solid Electrolyte. Japanese pat. 73 45,831, June 30, 1973, 3 pp.
[30] Chemical Marketing Reporter. EPA Warns Stores To Halt Sales of Thallium Sulfate. V. 203, No. 13. Mar. 26, 1973, p. 26.

Table 14.—U.S. imports for consumption of thallium, by country

Country of origin	Compounds (gross weight)		Unwrought and waste and scrap	
	Pounds	Value	Pounds	Value
Belgium-Luxembourg	50	$785	--	--
Germany, West	208	3,245	100	$500
U.S.S.R.	--	--	441	1,230
Total	258	4,030	541	1,730

Minor Nonmetals

By Staff, Division of Nonmetallic Minerals—Mineral Supply

CONTENTS

GREENSAND [1]

Greensand (glauconite) continued in 1973 to be produced only by the Inversand Co., Clayton, N.J., a subsidiary of Hungerford and Terry, Inc. Production and sales data are withheld to avoid disclosure of company confidential data. Production in 1973 was approximately at the same rate as in 1972.

Most of the product was treated and used by the parent company in its line of water conditioning equipment. Crude greensand was also used as a soil conditioner in agriculture.

A cooperative agreement continued between the Federal Bureau of Mines and the Geological Survey of the State of Delaware to develop new uses for greensand. Possible use in treating industrially polluted water was being considered, and various water samples were analyzed to determine the basic chemistry involved.

IODINE [2]

Consumption of crude iodine did not change appreciably from 1972, and there was a continued supply surplus for most of 1973. Industry stocks were still high in late 1973, although lower than a year ago. Domestic output, which represented a small part of overall supply, decreased considerably as compared with 1972, whereas imports showed no great change.

Crude iodine production in non-Communist countries dropped by possibly 400,000 pounds or 2%, almost all accounted for by Japan. Output by Chile, the world's second ranking iodine producer, was close to the 1972 level. Japan increased the price of its iodine from $1.86 per pound to $2.06, and was virtually the sole supplier of iodine to the United States for the second straight year. Chile cut the price of its iodine from $2.27 to $2.06 per pound in the hope of meeting Japanese competition. Domestic iodine was still quoted at $2.27, and there seemed to be some difficulty in selling at this price. The price of Japanese iodine went up abroad, directly as a result of the upward evaluation of the yen which subsequently declined slightly by yearend.

Legislation and Government Programs.—On December 31, 1973, the Government strategic stockpile contained 2,955,842 pounds of crude iodine and the supplemental stockpile 5,055,972 pounds for a total of 8,011,814 pounds. The stockpile objective for iodine, established by the Office of Preparedness, was reduced from 7.4 million pounds to nothing in early 1973. However, there were no disposals of iodine from the Government stockpile in 1973, because of the lack of Congressional approval.

[1] Prepared by William F. Keyes, physical scientist.
[2] Prepared by K. P. Wang, supervisory physical scientist.

Table 1.—Crude iodine consumed in the United States

Products	1972 Number of plants	1972 Crude iodine consumed Thousand pounds	1972 Crude iodine consumed Percent of total	1973 Number of plants	1973 Crude iodine consumed Thousand pounds	1973 Crude iodine consumed Percent of total
Resublimed iodine	6	600	11	6	689	12
Potassium iodide	10	1,514	29	10	1,568	27
Sodium iodide	4	90	2	4	W	W
Other inorganic compounds	14	983	19	17	1,059	18
Organic compounds	19	2,071	39	19	2,454	43
Total	[1] 30	5,258	100	[1] 32	5,770	100

W Withheld to avoid disclosing individual company confidential data; included with "Other inorganic compounds."
[1] Nonadditive total because some plants produce more than one product.

Domestic Production.—The Dow Chemical Co., the only domestic producer, recovered crude iodine from well brines at Midland, Mich., as a coproduct with bromine, calcium and magnesium compounds, and potash. The process employed has been used since the start of operations in 1964. Compared with 1972, ouput decreased by approximately 20%.

Consumption and Uses.—Based upon a Bureau of Mines canvass, approximately 5.77 million pounds of crude iodine was consumed by 32 firms in 13 States. Leading iodine-consuming States in 1973, in descending order of magnitude, were Missouri, New York, Pennsylvania, and New Jersey which together accounted for more than four-fifths of the total crude iodine consumption.

The above information is indicative of the consumption pattern, but is not necessarily completely comprehensive. Iodine and iodides used as catalysts and "dissipative" uses in general, particularly in making synthetic rubber, are not well covered. Imports alone have been consistently higher than reported consumption, with net differences as follows, in thousand pounds: 1970, 981; 1971, 2,473; 1972, 949; and 1973, 348. A more exact estimate of apparent consumption cannot be published, as U.S. production figures for crude iodine cannot be revealed.

Iodine consumed in making immediate downstream products, such as resublimed iodine, potassium iodide, sodium iodide, and organic iodine-containing compounds, have not shown any radical changes in recent years. As for ultimate downstream uses, the major categories for 1973 were roughly as follows, in order of descending importance as consumers of iodine: Catalysts (in rubber), food supplements, stabilizers (in nylon), inks and colorants, pharmaceuticals, sanitary uses, and photographic uses. Iodine was also consumed in making high-purity metals, motor fuels, iodized salt, photographic chemicals, smog inhibitors, swimming pool sanitizers, and lubricants.

Prices.—The price of Japanese iodine went up to $2.06 per pound around mid-February 1973. U.S. iodine was quoted at $2.27 all year, whereas Chilean iodine was brought down from the U.S. price to the Japanese level in mid-1973. As usual, prices had little to do with supply and demand, since an oversupply situation was accompanied by high prices. Quoted prices for iodine and iodine compounds at yearend 1973 were as follows:

	Per pound
Crude iodine, drums	$2.06–$2.27
Resublimed iodine, U.S.P., drums, f.o.b. works	3.97– 4.00
Calcium iodate, drums, delivered	2.50– 2.80
Calcium iodide, 35-pound drums, f.o.b. works	5.98
Potassium iodide, U.S.P., crystals, drums, 1,000-pound lots, delivered	2.60– 3.15
Sodium iodide, U.S.P., crystals, 300-pound drums, freight equalized	3.50– 3.91

Source: Chemical Marketing Reporter.

Foreign Trade.—Crude iodine imported into the United States in 1973 declined by 1.4% in quantity as compared with 1972, but total value increased 3.0%. The average value (f.o.b. originating country) of imported crude iodine rose from $1.64 per pound in 1972 to $1.71 in 1973, reflecting primarily changes in Japanese prices and discounts during actual transactions. About 6.1 million pounds of crude iodine was im-

Table 2.—U.S. imports for consumption of crude iodine, by country

(Thousand pounds and thousand dollars)

Country	1971		1972		1973	
	Quantity	Value	Quantity	Value	Quantity	Value
Chile	2,950	5,679	--	--	88	160
Japan	4,325	5,831	6,207	10,184	6,030	10,324
Total	7,275	11,510	6,207	10,184	6,118	10,484

ported, almost all from Japan. In an oversupply situation, high-priced Chilean iodine was hardly attractive in the U.S. market. Imports of resublimed iodine were nominal as compared with imports of crude iodine.

World Review.—*Chile.*—Production of crude iodine in 1973 as a byproduct of nitrates probably was less than 2,500 short tons. Output was on the low side for Chile, but even the upper limit would not be much greater, since iodine extraction is primarily controlled by nitrate production. The change in Chile's Government, marketing difficulties, and operating problems were factors holding back production.

Chile's three iodine plants, namely, Valdivia, Victoria, and Elena, were all owned by Sociedad Química y Minera de Chile S.A. (SOQUIM). The two latter plants were run at full capacity during most of the year. However, Valdivia, the most modern and largest plant, had not yet totally recovered from a major fire in late 1971 and may not be able to produce as much as previously without basic repairs requiring large additional investment.

Chile priced itself out of the U.S. market during all of 1972 and most of 1973, shipping almost completely to European and Latin American countries and the People's Republic of China. Lowering iodine price from $2.27 per pound to $2.06 did not result in immediate better sales, although small shipments started to arrive in the United States near yearend.

China, People's Republic of.—An estimate of China's iodine output is not possible, although the quantity is known to be small. Some iodine reportedly has been produced at the Haifang seawater salt processing plant in Amoy, Fukien Province, and the Peihai chemical plant of the Pingkuei Mining Administration in Kwangsi Province. Recently recovery of iodine and bromine from complex salts was started at the Yuncheng salt basin in southern Shansi Province at the "Chin Chien-cheng Chemical Industry Base."[3] China is short of iodine, making up the deficiency mainly through imports from Chile with whom trade agreements specify shipments of approximately 660,000 pounds annually. Exports from Japan to China were only 8,800 pounds in 1972 and 29,000 pounds during 1973.

Indonesia.—Abundant supplies of brackish water in many localities of Indonesia represent a significant potential source of iodine. Japanese and European firms both have been interested in these possibilities. In the fall of 1973, Ise Chemical Industries, Ltd., of Japan announced that it had applied to the Indonesian Government for approval to establish a joint venture with Mitsui & Co. and Indonesian interests.[4] Ownership would be 55% for the Japanese during the first 10 years and changing to 55% for the Indonesians thereafter. Specific locations were not mentioned, but development would take 3 or 4 years and eventual annual output may reach 1 million pounds of iodine.

Japan.—Japan continued to be the world's foremost iodine producer during 1973. Its output of 8,038 short tons of crude iodine, a decline of about 2.5% from the 8,240 tons produced in 1972, was still more than three times that of Chile, the only other major non-Communist nations producer. Over four-fifths of the Japanese production was exported, mainly to the United States which took about 3,015 short tons in 1973. Japan's other iodine markets included European Community countries, India, Switzerland, the U.S.S.R., and Canada.

Natural gas brines are the source of Japan's iodine which is recovered along with

[3] Ta-kung-pao (Peking). May 28, 1972, p. 1.
[4] Japan Chemical Week (Tokyo). Ise Chemical Eyes Joint Iodine Venture in Indonesia. V. 14, No. 699. Sept. 20, 1973, pp. 1, 5.

natural gas. Eighteen plants owned by five manufacturing groups provide the entire output. Except for one in Niigata in northwest Honshu, all iodine plants are located around Kujikurihama in Chiba Peninsula east of Tokyo. Only about one-third of the plants have been built in the last few years, and the older ones are having some operating problems.

Although Japan's crude iodine capacity was about 9,000 short tons per year at yearend 1973, possibly a third of this may not be operable in the near future because of ground subsidence difficulties related to withdrawal of brines and not pumping solutions back. Ise Chemical Industries, Ltd. (Ise Chemical), was the leading firm, with roughly half of the country's capacity and most of the best plants. In addition to its own seven plants, Ise Chemical runs a plant for Teikoku Oil Co. Ltd (Teiseki) and another one for United Resources (Godo). Godo, with two plants, had about one-fifth of Japan's capacity. Nippon Tennen (Nitten) with three plants and Kantoh Tennen (Kanten) with four plants each had just over one-tenth of the total capacity. Two sister companies, Nippon Chemical Industries and Nippon Halogen, have one plant each. At least three other firms, Teiseki, Tokyo Gas Co., and Fuji Boring Co., have been extracting natural gas in the Chiba City area, and they have agreed to abandon their wells by 1976.

The pattern of Japanese iodine production started to undergo basic changes in 1973. Japan's Environment Agency, the Ministry of International Trade and Industry, and Chiba Prefectural authorities initiated a series of stringent measures to protect the highly-populated area of Chiba from further ground subsidence and tidal wave flooding brought about in part by withdrawal of brines.[5] New wells will be prohibited except in special cases, existing wells will be abandoned if shown to be causing subsidence, water will be recycled if possible, water discharge will be controlled, and drilling will be coordinated. The net result means that Japan's iodine production capacity will decrease in the next few years, and an upturn will not take place until the second half of the 1970's. Ise Chemical's facilities in Chiba will suffer the least, and more new iodine operations will be developed by Teiseki and Ise in northeastern Honshu.

U.S.S.R.—Iodine apparently is produced at the Neftechlinski field, the Slavyansko-Troitskoe area near the Black Sea, and at a plant in the Baku area. Soviet iodine output may have tripled between 1966 and 1971, to 3.3 million pounds in the latter year.[6] Unknown, but probably not too large, quantities of iodine are presumably imported from Chile. Soviet iodine imports from Japan were about 250,000 pounds in 1972 and 330,000 pounds from January to October 1973.

LITHIUM [7]

Domestic output of lithium minerals and lithium carbonate from brines increased substantially over that of 1972, and was the largest ever reported. Imports for consumption of lithium minerals were 5 times the quantity imported in 1972.

Legislation and Government Programs.—The General Services Administration (GSA) sold 950 short tons of lithium hydroxide monohydrate during 1973. At yearend 5,540 short tons of lithium hydroxide monohydrate were held by GSA under the Federal Property Act.

Domestic Production.—Foote Mineral Co. mined and milled spodumene from pegmatites at Kings Mountain, N.C., and also recovered lithium carbonate from brines at Silver Peak, Nev. Lithium Corp. of America, a subsidiary of Gulf Resources and Chemical Corp., mined and milled spodumene near Bessemer City, N.C.; Kerr-McGee Corp. recovered lithium carbonate from brines at Trona, Calif.

Lithium Corp. of America completed an expansion of their mine and plant at Bessemer City, N.C., early in the year.

Processors of lithium raw materials to lithium primary products were Foote Mineral Co., Sunbright, Va., and Silver Peak, Nev., Kerr-McGee Corp., Trona, Calif., and Lithium Corp. of America, at Bessemer

[5] Japan Chemical Week (Tokyo). Iodine Production Hard Hit by Subsidence of the Ground in Chiba. V. 14, No. 705, Nov. 1, 1973, p. 2.

[6] Chemical Marketing Reporter (New York). Iodine Supply, Now Plentiful, Looks Destined to Tighten Up Over the Coming Three Years. V. 203, No. 10, Mar. 5, 1973, p. 3 and p. 23.

[7] Prepared by Donald C. Wininger, physical scientist.

City, N.C. Production data were not available for publication.

Consumption and Uses.—Domestically produced lithium minerals were processed into numerous lithium chemicals for a wide variety of applications. Major uses were in primary aluminum production, ceramics, greases, air conditioning, alloying, welding and brazing, swimming pool sanitation, and organic synthesis.

Although consumption of most lithium compounds increased during the year, sales of lithium carbonate to the aluminum industry continued to show the most significant increase. A special grade of high-purity lithium carbonate is being used in the production of photochromic optical glass. This is a specialized but growing market.[8]

Prices.—Domestic prices of lithium minerals are usually determined by direct negotiation between buyer and seller and are seldom published. However, Ceramic Industry, in January 1973, listed prices for spodumene supplied to the ceramic industry ranging from $77 to $89.50 per ton, unchanged from the previous year.

Prices for the major lithium compounds at yearend were quoted in the Chemical Marketing Reporter as follows:

	Per pound
Lithium metal, 1,000-pound lots or more delivered	$8.18
Lithium bromide, anhydrous, drums, ton lots, delivered	1.70
Lithium carbonate, powder, carlots, truck loads, delivered	.555
Lithium chloride, anhydrous, carlots, truck loads, delivered	.94
Lithium fluoride, carlots, truck loads, delivered	1.63
Lithium hydride, carlots, truck loads, delivered	8.05
Lithium hydroxide, monohydrate, carlots, truck loads, delivered, in drums	.63
Lithium nitrate, technical 100-pound lots, in drums	1.25–1.55
Lithium stearate, 50-pound cartons, carlots, works, freight allowed	.61–.64
Lithium sulfate, 100-pound lots, in drums	1.20–1.30

Foreign Trade.—Exports of lithium hydroxide declined from 1,097,175 pounds valued at $595,232 in 1972 to 1,043,459 pounds valued at $604,730 in 1973. Quantitative data on exports of lithium minerals and lithium metal, alloys, and other compounds were not available. Domestic imports of lithium minerals were 5 times the 1972 level. Brazil supplied 87% of all the imports. Imports of lithium compounds were 22,298 pounds valued at $82,312, principally from France (83%) and the United Kingdom (14%) with small amounts from Canada and West Germany.

World Review.—*Canada.*—In Manitoba the Chemalloy Minerals subsidiary, Tantalum Mining Corp., began production of lithium concentrates from a 150-ton-per-day pilot mill at its Bernic Lake mine site in early May.[9] If the results of this work are favorable, the plant will be expanded to between 350 and 450 tons per day.

Technology.—Lithium battery development work continued at a high level during the year. A number of articles in the Journal of the Electrochemical Society during the year reported on the results of various phases of the research.

Table 3.—U.S. imports for consumption of lithium ore, by country of origin and U.S. customs district

Country and customs district	1972 Quantity (short tons)	1972 Value (thousands)	1973 Quantity (short tons)	1973 Value (thousands)
Baltimore district:				
Australia	1,215	$33	--	--
Brazil	--	--	5,303	$334
South Africa, Republic of	--	--	565	47
Pembeina: Canada	--	--	205	51
Total	1,215	33	6,073	432

GTE Laboratories Inc. announced the development of an experimental lithium battery which is said to produce 8 times more energy than a conventional flashlight cell and has a life of more than 2 years. "Initial applications may be in flashlights, portable radios, calculators, cameras, hearing aids, wrist watches and other portable battery powered products."[10]

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[8] Williams, T. A. Lithium. Min. Eng., v. 25, No. 2, February 1974, p. 114.

[9] The Northern Miner. Lithium on Stream at Tantalum Mining. V. 59, No. 13, June 14, 1973, p. 1.

[10] American Metal Market. Longer Life, High Energy Content Claimed for New Lithium Battery. V. 80, No. 165, Aug. 23, 1973. p. 7.

Table 4.—Lithium minerals: World production by country

(Short tons)

Country [1]	Mineral produced	1971	1972	1973 p
Argentina	Not specified	89	54	e 55
Australia	do	1,846	1,180	e 1,200
Brazil [2]	do	5,292	--	5,303
Canada [2]	Spodumene	--	--	205
Mozambique	Lepidolite	772	--	--
Portugal	do	827	1,323	1,102
Rhodesia, Southern [3]	Not specified	67,000	67,000	67,000
South Africa, Republic of	Spodumene	1	--	--
South-West Africa, Territory of [4] e	do	r 5,035	4,130	5,914
United States	Not specified	W	W	W

e Estimate. p Preliminary. r Revised. W Withheld to avoid disclosing individual company confidential data.

[1] In addition to the countries listed, others (notably the U.S.S.R.) may produce lithium minerals, but available information is inadequate to make reliable estimates of output levels.

[2] U.S. imports from listed producing country.

[3] Output has not been reported since 1964, but presumably has continued. Figures given are simply the 1964 output level rounded to the nearest thousand tons, and are presented only to indicate order of magnitude of previous production, there being no assurance that the output level has not varied (see also footnote 4). In 1964, total reported production was distributed as follows by mineral, in short tons: Eucryptite—806; lepidolite—22,943; petalite—36,449; spodumene—6,965.

[4] Output has not been reported since 1966, but presumably has continued, inasmuch as a number of countries record imports from "South Africa." Estimates given represent total reported imports from South Africa by the United States and the European Community less the reported output of the Republic of South Africa. These quantities, however, may include significant amounts originating in Southern Rhodesia (see footnote 3) rather than in the Territory of South-West Africa. In 1966, total reported production was distributed as follows, by mineral, in short tons: Amblygonite—30; lepidolite—365; petalite—1,344.

MEERSCHAUM [11]

No imports of crude meerschaum were reported in 1973. The United States does not produce meerschaum and is dependent upon foreign sources. Historically, over a 53-year period, 1920–72, the United States has imported approximately 722,400 pounds of crude meerschaum, valued at approximately $1.46 per pound. Primary domestic use of the meerschaum has been in smoking articles, such as pipes and cigarrette holders.

Meerschaum from Turkey has accounted for about 80% of the total 722,400 pounds exported to the United States. Other sources have been Austria, Belgium and Luxembourg, France, Italy, India, Iran, Japan, Kenya, Somali Republic, and the Republic of South Africa.

QUARTZ CRYSTAL [12]

ELECTRONIC-GRADE

Total raw natural and manufactured crystal consumption increased 32% over that of 1972. Consumption of manufactured quartz exceeded that of natural quartz, but consumption of both categories increased. Domestic manufactured quartz production increased significantly. Imports of natural quartz and exports of natural and manufactured quartz also increased. Production of finished crystals showed a small increase.

Legislation and Government Programs.—During 1973 the Government reduced the stockpile objective from 320,000 pounds to 209,000 pounds of electronic-grade quartz crystal. The GSA continued to sell excess stockpiled quartz crystal. The Defense Materials Inventory declined from 4.34 million pounds of stockpile-grade and 352,960 pounds of nonstockpile-grade material at the end of 1972 to 4.05 million pounds of stockpile-grade material and 175,096 pounds of nonstockpile-grade material at the end of 1973.

Domestic Production.—There was no reported domestic production of natural electronic-grade quartz crystal during 1973. At yearend six companies reported production of manufactured quartz for use by the quartz crystal cutting industry. These companies were P.R. Hoffman Co., Carlisle, Pa.; Motorola, Inc., Chicago, Ill.; Quality Crystals, Inc., Cortland, Ohio; Sawyer Research Products, Inc., Eastlake, Ohio;

[11] Prepared by Arthur C. Meisinger, industry economist.

[12] Prepared by Benjamin Petkof, physical scientist.

Thermodynamics Corp., Shawnee Mission, Kans.; and Western Electric Co., Inc., North Andover, Mass. The firms producing manufactured quartz remained unchanged from the previous year. Manufactured quartz production increased 30% from the quantity reported in 1972 to 207,541 pounds.

As of May 1, 1973, all the outstanding shares of Sawyer Research Products, Inc. were purchased by Brush Wellman, Inc., of Cleveland, Ohio. Brush Wellman, Inc., announced an expansion of Sawyer's facilities to meet the increasing demand for quartz crystal.

Table 5.—Salient electronic- and optical-grade quartz crystal statistics

(Thousand pounds and thousand dollars unless otherwise noted)

	1971	1972	1973
Production of manufactured quartz	110	160	208
Imports of electronic- and optical-grade natural quartz crystal			
Quantity	35	65	104
Value	76	78	92
Exports of electronic- and optical-grade quartz crystal			
Quantity	174	149	287
Value	1,626	1,228	3,283
Natural:			
Quantity	113	90	205
Value	833	587	1,933
Manufactured:			
Quantity	61	59	82
Value	793	641	1,350
Consumption of raw electronic-grade quartz crystal	133	189	249
Natural	62	87	99
Manufactured	71	102	150
Production piezoelectric units, number ... thousands	20,924	25,555	27,006

Consumption and Uses.—Total raw quartz crystal consumption increased from 189,078 pounds in 1972 to 248,929 pounds in 1973. Consumption of natural quartz increased 14% from 87,157 pounds in 1972 to 99,395 in 1973. Manufactured quartz consumption increased 47% from 101,921 pounds to 149,534 pounds in 1973. The consumption of manufactured quartz exceeded that of natural quartz for the third consecutive year. The number of finished crystal units fabricated from raw quartz (natural and manufactured) consumed during the year reached 27 million units. The 1973 consumption data reported in table 5 are based on reports received from 32 crystal cutters in 13 States. Finished piezoelectric units were produced by 28 of the cutters, the remainder produced only semifinished blanks. Of these, two consumed natural quartz only, 19 cut manufactured quartz only, and 11 cut both natural and manufactured quartz. Thirteen consumers in four States accounted for 86% of the raw quartz crystal consumption. Pennsylvania was the leading quartz-consuming State with 42% of the total, followed by Illinois, Kansas, and Massachusetts.

Piezoelectric units were manufactured by 36 producers in 16 States. Nine of these producers worked from partially processed quartz crystal blanks and consumed no raw quartz (natural or manufactured). Fourteen plants in four States, Kansas, Illinois, Pennsylvania, and Massachusetts, supplied three-fourths of the total output of finished crystal units. Oscillator plates comprised 82% of production. The remainder included filter plates, telephone resonator plates, and other miscellaneous items.

Stocks.—At yearend, stocks of raw quartz crystals held by consumers totaled 114,205 pounds. Of this total 90,886 was natural material and 23,319 was manufactured quartz.

Foreign Trade.—U.S. exports of natural quartz crystal increased 128% from 90,246 pounds in 1972 to 205,420 pounds in 1973. Exports of manufactured quartz increased 40% from 58,914 pounds in 1972 to 82,241 pounds in 1973. The average price of natural quartz crystal exported was $9.43 per pound; that of manufactured quartz was $16.46 per pound.

Imports of electronic- and optical-grade natural quartz crystal, valued at more than $0.50 per pound, increased in both quantity and value in 1973 to 103,569 pounds and $92,258, respectively. This was an increase of 59% in quantity and 18% in value from the previous year's totals. The average value of imports was $0.89 per pound, a decline of 26% from the previous year's average value of $1.20 per pound. Brazil supplied 90% of the total imports of electronic-grade natural quartz. The remainder was supplied by the United Kingdom, France, West Germany, Japan, Malagasy Republic, and the Republic of South Africa.

A total of 961,205 pounds of lasca, valued at $271,332 was imported in 1973, an increase of 40% in quantity and 7% in value from 1972 data. The average value of imported material was $0.28 per pound. Lasca was used to manufacture fused quartz and as a nutrient material in the production of manufactured quartz crystal. Brazil provided 96% of total lasca imports, and the remainder was received from Japan.

World Review.—*Brazil.*—The Nation was the dominant world producer of natural quartz crystal. Exports of quartz crystal for electronic use totaled 783,000 pounds valued at $429,000 in 1973. In addition, 2 million pounds of lasca, valued at $1.4 million was exported.

Technology.—A device, using a coated piezoelectric crystal (quartz), has been developed for the detection and measurement of sulfur dioxide. The response of the device was observed as a function of sample size, weight of substrate application to the crystal, sulfur dioxide concentration, and sample volume. The instrument is rugged, portable, low cost and amenable to automation.[13]

Single crystals of ferroelectric lithium tantalate were grown as an alternate material for quartz crystal in the manufacture of piezoelectric resonator and filter devices. The lithium tantalate crystals were grown by the Czochralski crystal pulling technique.[14]

A paper was presented describing the hydrothermal synthesis of quartz and the manufacturing facility of a major producer. The advantages of manmade quartz, industry facts, the recent industry developments were discussed.[15]

STAUROLITE [16]

Staurolite is a complex hydrated ferrous-aluminosilicate mineral, some properties of which may differ from one specimen to another, implying some variability of composition. The mineral most commonly occurs as opaque reddish-brown to black crystals with a specific gravity ranging from 3.65 to 3.77 and between quartz and topaz in hardness (7 to 8 on Moh's scale). Aside from a small rock-shop trade in cruciform-twinned crystals from some deposits ("fairy crosses") that are sold as curiosities or amulets, staurolite is produced commercially in the United States only in the form of a magnetic fraction from heavy-mineral concentrates recovered by E. I. du Pont de Nemours & Co. from a deposit of ice age beach sand in Clay County, Fla.

Formerly the staurolite fraction so obtained was used mostly in portland cement mixtures, but more recently this product (with minor admixtures of several other minerals) is being marketed by Du Pont under two trade names, "Starblast" for use as a sandblast abrasive, and "Biasil" for mixing with bentonite and other substances to serve as a foundry sand in some specialized molding applications. Increasing industrial demand for these products can be inferred from the observation that the ratio of staurolite shipments to staurolite production, which had averaged around 1:2 in the 1965 to 1969 period, has been well over 1:1 in every year since, pointing to a substantial movement of previously stockpiled material. Quantitative data are not released for publication, but the 1973 production of staurolite was 60% greater than that of 1972, while shipments increased 22% in tonnage and 37% in total value.

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[13] Frechette, M. W., and James L. Fashing. Simple Piezoelectric Probe for Detection and Measurement of SO_2. Environmental Sci. and Tech. v. 7, No. 13, December 1973, pp. 1135–1137.

[14] Rudd, D. W., and A. A. Ballman. Growth of Lithium Tantalate Crystals for Transmission Resonator and Filter Devices. Solid State Tech., v. 17, No. 1, January 1974 pp. 52–55.

[15] Lias, N. C. Hydrothermal Synthesis of Quartz: A Growing Industry. Soc. Mining Eng. of AIME., Preprint 73-H-59, 1973, 21 pp.

[16] Prepared by J. Robert Wells, physical scientist.

STRONTIUM [17]

Domestic consumption of strontium on a strontium carbonate basis was estimated at 33,000 short tons in 1973, representing a 5% increase over the previous year. Although imports of strontium minerals declined for the second year, imports of strontium chemicals, primarily from Canada, increased ninefold compared with 1972.

Legislation and Government Programs.—The Government sold 8,010 short tons of stockpile-grade celestite during 1973. Government stockpiles contained 4,052 tons of stockpile-grade and 14,408 tons of nonstockpile-grade celestite at yearend.

Domestic Production.—Strontium minerals have not been produced commercially in the United States since 1959. However, a number of firms produced various strontium compounds from imported celestite.

Consumption and Uses.—Domestic consumption of celestite in the manufacture of various strontium chemicals declined from the 1971 high. Quantitative information concerning consumption is incomplete, however, one leading company reported a slight increase in 1973 over 1972. Sales of domestically produced strontium carbonate to manufacturers of glass for color television picture tubes declined considerably from 1972. The trend of celestite consumption in the manufacture of chemicals for pyrotechnics was not clear.

Miscellaneous applications for strontium compounds included ferrites, greases, ceramics, plastics, toothpaste, pharmaceuticals, paint, electronic components, welding fluxes, and high-purity zinc. Small quantities of imported strontium metal were used primarily by research companies.

Table 6.—Major producers of strontium compounds, 1973

Company	Location	Compounds
Atomergic Chemetals Co	Carle Place, N.Y	Various compounds.
J. T. Baker Chemical Co	Phillipsburg, N.J	Do.
Barium & Chemicals, Inc	Steubenville, Ohio	Do.
Chemical Products Corp	Cartersville, Ga	Carbonate.
E. I. du Pont de Nemours & Co., Inc	Grasselli, N.J	Nitrate.
FMC Corp	Modesto, Calif	Carbonate, hydrate, nitrate.
Hercules, Inc	Glens Falls, N.Y	Chromate.
King Laboratories Inc	Syracuse, N.Y	Metal alloys.
Mallinckrodt Chemical Works	St. Louis, Mo	Various compounds.
Mineral Pigments Corp	Beltsville, Md	Chromate, molybdate.
NL Industries, Inc., Tam Div	South Amboy, N.J	Titanates.

Prices.—At yearend, prices quoted in The Chemical Marketing Reporter were as follows: Strontium carbonate—technical, bags, carlots, works, at 13 to 21 cents per pound; strontium nitrate—bags, carlots, works, at $15 per 100 pounds, unchanged from the previous year. Prices for strontium minerals are usually determined by direct negotiation between buyer and seller and are seldom published. The average value of imported strontium minerals at foreign ports was $24.63 per short ton.

Foreign Trade.—Imports of strontium minerals totaled 27,040 tons, a 12% decline from 1972. The material was imported from Mexico, Spain, and Guatemala. Imports of strontium compounds increased 9 times over those of 1972 with most of the material coming from Canada (94%). In addition to the items listed in table 8, 4,189 pounds of organic strontium salts valued at $4,229 from the United Kingdom and 50 pounds of strontium metal valued at $375 from Canada were imported during 1973. Quantitative data on U.S. exports of strontium compounds were not available.

Table 7.—U.S. imports for consumption of strontium minerals,[1] by country

Country	1972 Quantity (short tons)	1972 Value (thousands)	1973 Quantity (short tons)	1973 Value (thousands)
Guatemala	--	--	73	$2
Mexico	27,791	$721	22,558	555
Spain	--	--	4,409	100
United Kingdom	2,886	109	--	--
Total	30,677	830	27,040	657

[1] Strontianite or mineral strontium carbonate and celestite or mineral strontium sulfate.

[17] Prepared by Donald C. Wininger, physical scientist.

Table 8.—U.S. imports for consumption of strontium compounds, by country

Country	1972		1973	
	Pounds	Value	Pounds	Value
Strontium carbonate, not precipitated:				
Austria	--	--	1,666	$1,155
Canada	68,300	$43,703	848,000	90,188
Germany, West	10,098	3,700	5,512	2,651
Total	78,398	47,403	855,178	93,994
Strontium carbonate, precipitated:				
Belgium-Luxembourg	--	--	79,366	19,420
Canada	405,850	40,802	9,392,385	1,026,838
Italy	--	--	342,431	82,101
Total	405,850	40,802	9,814,182	1,128,359
Strontium chromate:				
Canada	--	--	616,000	408,571
Germany, West	5,004	2,471	--	--
United Kingdom	4,409	2,250	--	--
Total	9,413	4,721	616,000	408,571
Strontium nitrate:				
Canada	605,100	76,580	76,596	10,437
Germany, West	1,000	1,029	1,761	729
United Kingdom	441	254	--	--
Total	606,541	77,863	78,357	11,166
Strontium compounds, n.s.p.f.:				
France	4,409	6,828	2,205	4,258
Germany, West	179,361	39,734	255,735	57,140
Japan	--	--	1	1,770
United Kingdom	--	--	2,070	5,040
Total	183,770	46,562	260,011	68,208
Grand total	1,283,972	217,351	11,623,728	1,710,298

Table 9.—Strontium minerals: World production by country

(Short tons)

Country [1]	1971	1972	1973 p
Algeria	r 397	2,084	e 2,100
Argentina	2,356	1,208	e 1,210
Canada e	60,000	65,000	65,000
Iran [2]	330	e 330	e 330
Italy	920	810	e 810
Mexico	38,650	26,923	20,143
Pakistan	r 440	378	14
Spain	9,370	8,818	e 8,800
United Kingdom	10,746	4,850	4,782
Total	123,209	110,401	103,189

e Estimate. p Preliminary. r Revised.
[1] In addition to the countries listed, West Germany, Poland, and the U.S.S.R. produce strontium minerals, but available information is inadequate to make reliable estimates of output levels.
[2] Year beginning March 21 of that stated.

World Review.—*Canada.*—Kaiser Strontium Products Ltd. marketed strontium chemicals worldwide from its plant at Point Edward, Cape Breton Island, Nova Scotia. Technical problems, however, continued to delay commercial-scale production of glass-grade strontium carbonate.

Technology.—A report of experimental work was published on the purification of strontium metal by reactive distillation.[18]

A paper was published presenting the results of studies on the characterization and sintering behavior of barium and strontium ferrites.[19]

[18] Kaldis, E., J. Muheim, J. Evers, and A. Weiss. Purification of Strontium by Reactive Distillation. J. Less-Common Metals, v. 31, No. 1, April 1973, pp. 169–173.
[19] Reed, James S., and Richard M. Fulrath. Characterization and Sintering Behavior of Ba and Sr Ferrites. J. Am. Ceram. Soc., v. 56, No. 4, April 1973, pp. 207–211.

A process for the purification of celestite, to obtain a glass- or ceramic-grade strontium carbonate analyzing about 99% pure was patented.[20]

WOLLASTONITE [21]

Wollastonite, which is a metasilicate of calcium that theoretically consists of 48.3% lime combined with 51.7% silica and varies in structure from massive to tabular to fibrous, occurs chiefly as a contact mineral along certain igneous rock-limestone interfaces and often in association with some variety of garnet. Wollastonite from selected deposits has found increasing use as an ingredient in ceramic mixes for glazes and enamels and especially for floor and wall tile; in the building industry for the production of mineral wool and cold-setting insulation foams, as a pigment and extender for paints, and to enhance the cross-rupture strength of cement-asbestos siding, shingles, and drainpipe; as a filling and felting agent for plastics, rubber, and asphalt products; in agriculture as a fertilizer and soil conditioner; in some glass-making formulations; and in a wide variety of other applications still being developed.

Wollastonite was produced in the United States in 1973 from one underground mine operated by Interpace Corp. at Willsboro, Essex County, N.Y.; output tonnage was 25% greater than in 1972, and the corresponding total value was 28% higher, new alltime highs for both figures. Notably, the 1973 tonnage also surpassed that of 1966, the record year hitherto, by 12%.

Wollastonite has been mined in California intermittently since 1933, but no commercial production has been reported in that State since 1969. A new firm, Western American Minerals Co., was organized in early 1973 with the announced aim of mining and processing wollastonite from a deposit near Hunter Mountain in California's Inyo County. Adverse weather, specifically an unprecedented heavy snowfall on access roads, was blamed for delaying the start of operations beyond the target date.

Chemical Marketing Reporter quoted wollastonite prices in bags, carlots, works, at $43.80 per ton for paint grade, fine, and $33.00 per ton for paint grade, medium, unchanged (both quotations) December 1971 through December 1973. The average unit value reported for production, all grades, advanced twice, however, in that same period. American Paint Journal, December 31, 1973, reported the following prices for wollastonite, paint grade: Extra gliders, bolted, $35.00 to $50.50 per ton; medium, carlots, f.o.b. plant, $29.00 per ton. Ceramic Industry Magazine, January 1974, listed wollastonite prices in the range from $22.50 to $37.00 per ton. It is to be understood, however, that actual sales of wollastonite were arranged as usual at negotiated prices not publicly disclosed.

A report was issued that presented reported or estimated figures for wollastonite production in Kenya, India, Finland, Mexico, and the United States in the years 1967 through 1971.[22]

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[20] Trew, L. J. (assigned to Kaiser Aluminum & Chemical Corp.). Purification of Celestite To Obtain a Glass or Ceramic Grade Strontium Carbonate. U.S. Pat. 3,743,691, July 3, 1973.

[21] Prepared by J. Robert Wells, physical scientist.

[22] Institute of Geological Sciences, Mineral Resources Division. Statistical Summary of the Mineral Industry—World Production, Exports and Imports 1967–1971. Her Majesty's Stationery Office (London), 1973, p. 401.